PB87-189767

Superfund Record of Decision (EPA Region 3)
Army Creek Landfill Site
New Castle County, Delaware, September 1986

(U.S.) Environmental Protection Agency
Washington, DC

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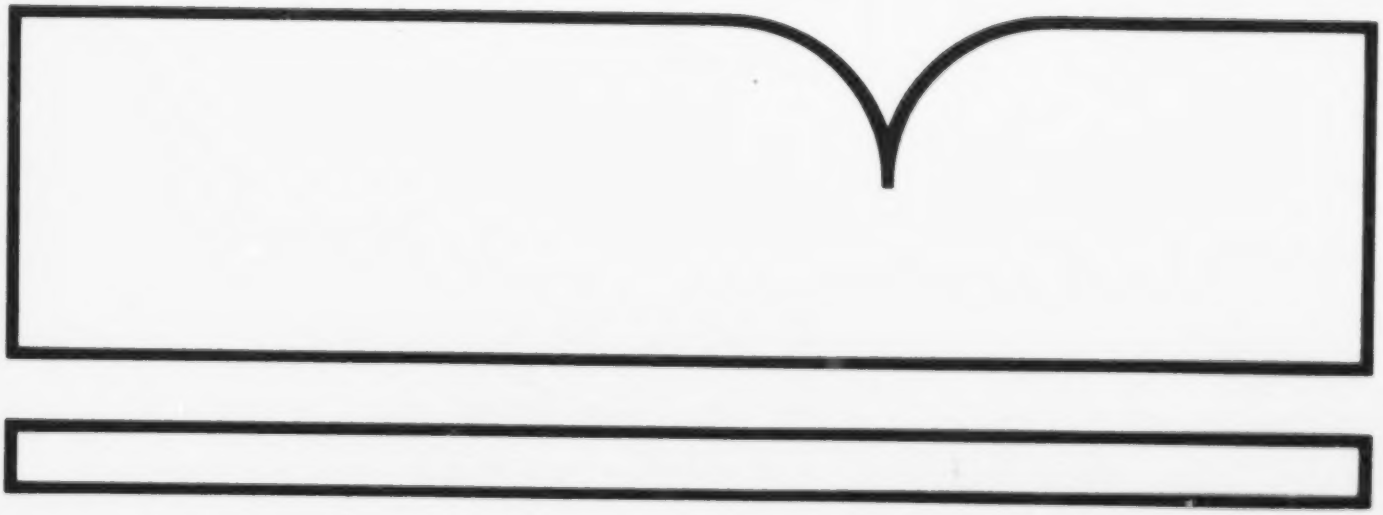

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EPA/ROD/R03-86/032
September 1986

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EPA

Superfund Record of Decision:

Army Creek Landfill, DE

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TECHNICAL REPORT DATA
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1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO
EPA/ROD/R03-86/032		PB87 189767/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
SUPERFUND RECORD OF DECISION Army Creek Landfill, DE	September 30, 1986 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO
9. PERFORMING ORGANIZATION NAME AND ADDRESS Same as box 12.	10. PROGRAM ELEMENT NO 11. CONTRACT/GRANT NO
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460	13. TYPE OF REPORT AND PERIOD COVERED Final ROD Report 14. SPONSORING AGENCY CODE 800/00

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Army Creek Landfill (ACL), formerly known as the Llangollen Landfill, is located approximately two miles southwest of New Castle, Delaware, and is adjacent to the Delaware Sand and Gravel Landfill Superfund site. ACL, a former sand and gravel quarry, is owned by New Castle County. The County operated this 44-acre landfill, which accepted municipal wastes, from 1960 until its closure in 1968 when it was filled to capacity. An estimated 1.9 million cubic yards of refuse were landfilled at the site, 30 percent of which (or approximately 600,000 cubic yards) now lies below the seasonal high water table. In late 1971, water in a residential well downgradient of the site developed quality problems. Results from a subsequent investigation showed that leachate, most likely originating from the Army Creek and Delaware Sand and Gravel Landfills, was contaminating local aquifers. This lead to the installation of a ground water recovery system designed to maintain a ground water divide between the landfills and the Artesian Water Company Wellfield located downgradient of the landfills. The primary contaminants of concern include: VOCs, inorganics, heavy metals, benzene, and chromium.

The selected remedial action for this site will be implemented in a two-phased approach. Phase 1: Install a RCRA type cap to minimize infiltration of rainwater. Capping of the landfill will include site clearing, regrading of the existing cover
(See attached sheet)

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field Group
Superfund Record of Decision Army Creek Landfill, DE Contaminated Media: soil, sediments, sw, gw Key contaminants: VOCs, inorganics, heavy metals, chromium		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report) None	21. NO. OF PAGES 58
	20. SECURITY CLASS (This page) None	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

16. ABSTRACT (continued)

surface, adding soil backfill to achieve grades, installing the cap with gas vents, and construction of drainage ditches to direct run-off away from the landfill; continue operation of the downgradient recovery well network; evaluate the capping system and the downgradient pumping network for five years after the cap is installed. This evaluation will include, but not be limited to, monitoring water levels, pumping rates and water quality. Phase 2: After the five year evaluation period, a determination will be made on whether to install upgradient controls to intercept lateral ground water inflow on the northwestern boundary of the landfill; continue monitoring the water levels, pumping rates and water quality as in Phase 1; O&M will include as a minimum, regular inspections and, as necessary, repairs to the RCRA cap. The ground water recovery system will be monitored to assure that it is capturing the contaminated plume. The estimated capital cost for this two-phased remedial action is $12,030,000, or $12,340,000 with upgradient controls. O&M costs are estimated at $306,000, or $388,000 with upgradient controls.

RECORD OF DECISION

REMEDIAL ALTERNATIVE SELECTION

Site: Army Creek Landfill Site, New Castle County, Delaware

Data Reviewed

The underlying technical information, unless otherwised specified, used for analysis of the cost-effectiveness and feasibility of remedial alternatives is included in the following documents and project correspondence. I have been briefed by my staff of their contents, and they form the principal basis for my decision of the appropriate extent of remedial action.

- Feasibility Study for the Army Creek Landfill, New Castle County, Delaware, (Roy F. Weston, Inc., July 1986)

- Endangerment Assessment, Army Creek Landfill (Richard L. Zambito, U.S. E.P.A. Region III, July 1984)

- Hydrogeochemical Studies at a Landfill in Delaware (Mary Jo Baedecker and Michael A. Apgar, 1984, Studies in Geophysics, Groundwater Contamination, National Academy Press)

- Recommendations by the Delaware Department of Natural Resources and Environmental Control

- Staff summaries and recommendations

Description of Selected Remedy

° An initial operable unit for source controls to be implemented in a two-phased approach.

Phase 1

° Install a RCRA type cap to minimize infiltration of rainwater. Capping of the landfill will include site clearing, regrading of the existing cover surface, adding soil backfill to achieve grades, installing the cap with gas vents, and construction of drainage ditches to direct run-off away from the landfill.

° Continue operation of the downgradient recovery well network.

° Evaluate the capping system and the downgradient pumping network for five years after the cap is installed to assess effectiveness of the system during operation. This evaluation will include, but not be limited to, monitoring water levels, pumping rates and water quality.

Phase 2

° After the five year evaluation period, a determination will be made on whether to install upgradient controls to intercept lateral groundwater inflow on the northwestern boundary of the landfill.

° Continue monitoring the water levels, pumping rates and water quality as in Phase 1.

° Operation and maintenance (O & M) will include as a minimum, regular inspections and, as necessary, repairs to the RCRA cap. The groundwater recovery system will be monitored to assure that it is capturing the contaminated plume.

Selection of a treatment alternative for the groundwater recovery well discharges has not been made at this time and will be the subject of a second operable unit decision document in the future. A groundwater treatment remedy has not been selected, because the final NPDES permit has not been issued. In addition, the Remedial Investigation/Feasibility Study (RI/FS) at the Delaware Sand & Gravel Superfund site adjacent to Army Creek Landfill, has not been completed. It is our intention to combine the remedial actions for these two sites wherever cost-effective.

Also being deferred at this time is a decision on appropriate remedial measures for sediments in Army Pond. This decision will be made at the same time as groundwater treatment is considered and after further analysis is accomplished regarding the actual impacts on Army Pond.

Declarations

Consistent with the Comprehensive Environmental Response and Compensation and Liability Act of 1980 (CERCLA) (42 U.S.C. § 9601-9657) and the National Contingency Plan (40 CFR Part 300), I have determined that the remedial action described above, together with proper operation and maintenance constitutes a cost-effective remedy which mitigates and minimizes damage to public health, welfare, and the environment. The remedial action provides for capping the site, continuing operation of existing downgradient groundwater recovery wells, and the installation of upgradient groundwater controls in the future as necessary and, therefore, minimizes the threat of further contamination of the environment. The remedial action does not affect or violate any areas. A portion of the remedy may encroach slightly into the floodplain at the south end of the site. If during detailed design, survey work establishes this, special measures will be taken to minimize the encroachment and to protect the remedy. The State of Delaware has been consulted and agrees with the approved remedy. In addition, the action will require future operation and maintenance activities to ensure the continued effectiveness of the remedies. These activities will be considered part of the approved action and eligible for Trust Fund monies for a period of six months following completion for construction.

///

I have determined that the action being taken is appropriate when balanced against the availability of Trust Fund monies for use at other sites.

9/23/86
DATE

JAMES M. SEIF
REGIONAL ADMINISTRATOR

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

A. SITE LOCATION AND DESCRIPTION

The Army Creek Landfill formerly known as the Llangollen Landfill, is located approximately two miles southwest of the city of New Castle, Delaware (Figure 1). The landfill is bordered to the north and west by tracks of the Penn Central Railroad and on the south and east by Army Creek. The highways adjacent to the Landfill are Routes 13 and 40 to the west and Route 9 to the east.

Llangollen Estates, a residential development is located 1/4 mile southwest of the site. The former Amoco Chemical Plant, closed in 1980 due to fire, is located 1/4 mile east of the site. Delaware Sand and Gravel, another landfill which has been placed on the Superfund National Priorities List, is adjacent to Army Creek Landfill and separated from it only by Army Creek, a tributary of the Delaware River.

The Army Creek Landfill, a former sand and gravel quarry is owned by New Castle County. The County operated this 44 acre landfill which accepted municipal wastes from 1960 until its closure in 1968. During that time, an estimated 1.9 million cubic yards of refuse were landfilled at the site, 30 percent of which (or approximately 600,000 cubic yards) now lies below the seasonal high water table.

In late 1971, water in a residential well southwest of the landfill developed quality problems, such as a distinctly disagreeable odor and permanent staining of porcelain fixtures. New Castle County and its consultant, Roy F. Weston, Inc., of West Chester, Pennsylvania, began a multi-year field investigation to assess the problem. Results from that investigation showed that leachate most likely originating from the Army Creek and Delaware Sand and Gravel Landfills, was contaminating local aquifers.

Weston's remedial investigation lead to the installation of a groundwater recovery system designed to maintain a groundwater divide between the landfills and the Artesian Water Company Wellfield located downgradient of the landfills. Contaminated groundwater pumped from the recovery well system was discharged to Army Creek.

In August 1984, EPA entered into a Consent Order with New Castle County to perform a Feasibility Study (FS) at the site.

B. SITE GEOLOGY

The Army Creek Landfill is located within the Atlantic Coastal Plain physiographic province. The coastal plain is composed of a wedge-shaped body consisting of gravels, sands, silts and clays.

The site is underlain by two water-bearing formations, the Columbia and the Potomac. The Columbia, the upper-most aquifer beneath the landfill, is of

Pleistocene Age and is from 10 to 60 feet thick at the site. This formation, which dips to the southeast, consists of medium to coarse grained sands, gravels, silts and clays which were deposited in shallow lens-shaped channels (Figure 2). The silt and clay units of the Columbia are discontinuous and do not form confining units.

The Potomac Formation of Cretaceous Age underlies the Columbia Formation and is generally separated from it by a confining clay layer at the site. The Potomac Formation dips to the southeast, is up to 600 feet thick and consists of silts and clays interbedded with sands and some gravel. The formation is divided into upper and lower units which are separated by a thick confining clay unit. The upper Potomac Formation silts and clays are discontinuous and non-uniform; in some places, the sands of the Columbia and Potomac are in contact.

C. Site Hydrogeology

Hydrologically, the Potomac upper clay functions as a confining zone for the underlying aquifer which is known as the upper Potomac Hydrologic zone. The direction of flow in the Potomac aquifer has been altered significantly over the past several decades due to withdrawal of water for industrial and domestic uses. The elevation of the potentiometric surface in the 1950's, before significant development of the aquifer, was about 6 meters below sea level and flow direction was toward Delaware Bay to the southeast. In the 1960's, after wellfields were developed in the Potomac Formation for public water supplies and industrial use, the direction of flow remained to the south and east.

Artesian Water Company, a private water company servicing 5,000 customers in this area, completed its first well at the nearby Llangollen Wellfield in 1952. By 1961, shortly after the Army Creek Landfill opened, there were four operating wells withdrawing water from the Llangollen Wellfield at an annual average rate of about 1.42 mgd (million gallons per day). In early 1966, Artesian completed a new well and had increased its average pumpage to approximately 1.62 mgd. In 1969, a sixth well was added and the annual average pumpage from the Llangollen Wellfield increased to about 1.74(mgd). In late 1971 and early 1972, five more wells were added to Llangollen Wellfield. By late 1971, Artesian had increased its pumpage to an annual average of 2.60 mgd. Since then, Artesian Water Company has had to decrease pumpage to 2 mgd in order to slow down the migration of the contaminants and to avoid contributing to the problems of salt water intrusion that had become common in the area. There has been considerable litigation between Artesian Water Company and New Castle County, over groundwater use. The precise amount of water which Artesian had withdrawn in the past, or is presently entitled to withdraw is unclear.

Amoco Chemical Company initiated groundwater withdrawal from the Potomac aquifer in 1961 for use in their plant operations. Pumpage by Amoco was discontinued in 1980 when the plant closed due to fire.

It has been estimated that pumpage from the upper Potomac aquifer had

increased more than seven fold from 1952 to 1972 as a result of groundwater withdrawals from Artesian's Llangollen Wellfield and the Amoco Chemical Company plant wells. During this period, it has been reported that the increased pumpage caused the static water level in Artesian's Llangollen wells to decline up to 65 feet. This decrease in water level resulted in a steepening of the hydrologic gradient in the upper Potomac aquifer which accelerated the migration of pollutants from Army Creek and Delaware Sand and Gravel Landfills toward the Artesian and Amoco production wells.

In late 1971, when one of the residential wells in the vicinity of the Army Creek Landfill, became contaminated with iron and other chemicals, New Castle County determined that the leachate generated by the landfill was contaminating the groundwater in the area. The leachate is produced by water entering the landfill in two ways:

1. Through direct precipitation on, and infiltration through, the landfill surface.

2. As groundwater moves laterally into the saturated lower portion of the landfill.

Analysis of water inflow to the landfill is accomplished by dividing the landfill into two sections (Figure 3). Section 1, the western section (estimated area = 760,000 square feet), receives both surface water and groundwater inflow, and generally has a continuous clay floor of relatively low permeability. As a result, there exists a relatively thick zone of saturation in this portion of the landfill.

Section 2, the older, eastern section of the landfill (estimated area = 1,350,000 square feet), receives water primarily by infiltration of direct precipitation. In the vicinity of Section 2, the contact between the Columbia and the upper aquifer of the Potomac Formation is often a quite permeable zone. Here the Potomac clay deposits are relatively thin, sandy, or are absent. Consequently, water in the Columbia sands moves downward to the Potomac aquifer rather than laterally through the landfill. In addition, the Columbia sands have been excavated northeast and south of the landfill. Therefore, elevations at these points and in the marsh to the east are lower than those of the landfill surface and, in places, lower than much of the Army Creek Landfill floor.

The surface of the landfill is pocketed with depressions resulting from the differential subsidence of the refuse. These depressions, coupled with the remaining flat surface of the landfill prevent stormwater from running off the landfill. The cover is generally silty, sandy and quite permeable. However, deposits of clay have accreted in the depressions so that stormwater forms ponds in the depressions. These ponds contribute to the slow infiltration of water into the landfill. Because of these surface conditions, it is estimated that at least 50 percent of the precipitation which falls directly onto the landfill surface infiltrates through the landfill cover and percolates through the refuse.

D. SITE HISTORY

The Army Creek Landfill occupies an area that was formerly utilized as a sand and gravel pit. The gravel pit in which Army Creek Landfill was constructed, was excavated until a hard zone was encountered. This zone marks the base of the Columbia Formation and the top of the underlying clay.

In 1960, the landfill began operation as a municipal refuse landfill. The landfill was operated by New Castle County continuously until 1968 when it was filled to capacity. Refuse placement, compaction and covering operations at the Army Creek Landfill were carried out by the operators of the gravel pit under contract to New Castle County. Refuse burial began at the eastern end of the pit and generally continued toward the pit entrance on the west. The refuse was generally not well compacted and not regularly covered. The cover material used was obtained from the pit and includes residential sands, tailing piles and siltation basin deposits. As the operation progressed, cover material and landfill space became depleted. This encouraged deeper excavation which may have removed much of the clay layer which separated the Columbia from the Potomac formations. This in turn, could have created direct access routes for leachate to the Potomac from the Columbia. Direct access routes may also have occurred naturally due to the non-continuous geometry of the Potomac clay.

Improper covering, along with non-consistent compaction and decomposition of the waste materials, may have contributed to the differential settling of the waste material which has occurred since the landfill was closed.

In 1970, the landfill was covered with sandy material and the property was purchased by the County for use as a park. In late 1971, water in a residential well downgradient of the Army Creek Landfill Site developed severe quality problems. Evidence of these problems was the odor of the water and staining of the porcelain fixtures in the residence. In June 1972, New Castle County commenced a groundwater monitoring program which began with a well installation and sampling program. Monitoring by various agencies including EPA, United States Geological Survey, (USGS) New Castle County and the Delaware Department of Natural Resources and Environmental Control (DNREC) as well as the University of Illinois has continued up to the present. Monitoring has resulted in the identification of groundwater contaminants indicative of hazardous waste disposal as well as typical municipal refuse. It was also determined that the plume of these contaminants was moving towards the receptors located downgradient of the landfill. After considering alternative water supplies for the affected residents, New Castle County paid for an extension of Artesian's Water supply lines to the first contaminated residence and other homes along Grantham Lane. There was also a settlement with the homeowners to offset the monthly services costs.

In 1973, recovery wells RW-1, RW-2, RW-3, RW-4, RW-5, RW-6,27,28,29, 31 and 53 were installed in the upper Potomac Aquifer by Roy F. Weston under the direction of New Castle County (Figure 4). The purpose of the recovery wells was to intercept and contain the contaminant plume. The pumping of these wells created a groundwater divide between the Army Creek Landfill and the Artesian Water Company's Llangollen Wellfield. Beginning in 1977, the

recovery wells showed a pattern of stability in water quality.

In November 1977, New Castle County conducted a technical Round Table Conference in order to obtain input and opinions from nationally and internationally recognized authorities regarding the remediation of the contaminated groundwater in the vicinity of the landfill. As a result of the Technical Round Table Conference, a modified recovery system was installed in 1980, which included placement of new recovery wells closer to the landfill in order to pump more concentrated groundwater and therefore less clean water. The present recovery well system utilizes Wells 27, 28, 29, 31, RW-1, RW-9, RW-10, RW-11, RW-12, RW-13, and RW-14.

US EPA has been involved at the site since 1974, when EPA representatives sampled the recovery wells for the first time. Since then, EPA has sampled the wells in 1977, 1978 and 1981 for priority pollutants. Based on the sampling analysis from the recovery and monitoring wells, the Army Creek Landfill site was proposed for the National Priorities List (NPL) in October of 1981 and was finalized on the list in September of 1983 due to extensive groundwater contamination.

In August 1984, EPA entered into a Consent Agreement and Order with New Castle County to perform a Feasibility Study at the site. New Castle County submitted the final draft of the study in July 1986.

E. CURRENT SITE STATUS

Groundwater

Since early 1972, intensive field studies have been conducted by the County, through its consultant Roy F. Weston, Inc., to evaluate the nature and the extent of the problem and to define and implement necessary controls to mitigate the groundwater contamination. These efforts included the installation and operation of the recovery wells in 1973, and monitoring and sampling of the recovery and monitoring wells.

The analytical results from the various sampling efforts have demonstrated that the following organic constituents are present in the groundwater: benzene, 1,2,dichloropropane, methylene chloride, 2,4,-dinitrotoluene, n-nitrosodimethylamine, 2,4,6-trichlorophenol, bis(2chloroethyl)ether and chlorodibromomethane. These contaminants have been detected in concentrations above levels set in drinking water standards (Table 1).

Inorganic contaminants were also found in water collected from monitoring and recovery wells. The contaminants include, beryllium, cadmium, chromium, lead, mercury, nickel, iron and manganese in concentrations above the levels set in drinking water standards (Tables 2,3,4).

Surface Water

In 1981, the EPA field investigation team sampled Army Creek for priority pollutants. The data indicated the presence of organic and inorganic contaminants in the waters of Army Creek. Organics detected included phenol, bis(2-ethylhexyl)phthalate, butyl benzylphthalate and di-n-butylphthalate (Table 5). Inorganics detected were aluminum, barium, cobalt, copper, iron, manganese, zinc, boron, calcium, magnesium and sodium (Table 6).

Additional water quality sampling for priority pollutant compounds was conducted by Weston for New Castle County in 1983 in connection with their NPDES permit application . Samples were analyzed by the New Castle County Laboratory. No volatile or extractable organic compounds were detected. The base/neutral organic compounds detected were bis(2-ethylhexyl) phthalate and di-n-butyl phthalate (Table 7). Upstream concentrations of both compounds were greater than downstream concentrations. All values were well below their respective ambient water quality criteria. Total metals were also analyzed in 1983. Of the metals analyzed from the water samples, cadmium, lead, mercury, nickel, and iron were found at higher concentrations upstream than downstream. Copper, silver, chromium, zinc, and manganese were found downstream at higher concentrations than upstream. Cadmium and mercury were the only parameters exceeding water quality criteria upstream and downstream of the pond (Table 8).

The State of Delaware, in connection with the remedial investigation at Delaware Sand and Gravel, conducted surface water sampling along Army Creek. No priority pollutants were found to exceed any water quality criteria.

Sediments

DNREC conducted sediment analysis in connection with the remedial investigation at Delaware Sand and Gravel (Table 9). Eight locations were sampled: six along Army Creek and Pond; one in a gravel pit pond as background and one at an intermittent stream east of Delaware Sand and Gravel. A comparison of this data with the clean stream sediments indicates that the Army Creek sample concentrations are considerably higher than those of the clean streams. Utilizing Station 7, the gravel pit pond for comparison and as a local background source, it is evident that samples taken from Army Creek and Pond have higher concentrations of all the metals detected. The iron and manganese concentrations in particular show an increasing trend in the downstream direction. Other metal concentrations peak at the pond entrance. Therefore, sediments have also been effected by the recovery well discharges.

Bioassays

Also in September 1973, a series of surface water and biotic surveys for Army Creek and Pond was initiated, to evaluate the affects of the recovery well discharges on the surface water system. Furthermore, in the past 13 years of discharges, Roy F. Weston, EPA and the State have taken numerous surface and sediment samples to determine if high levels of contaminants exist in the Army Creek and Pond and if so, what the affects of the contaminants have been. Overall, the results of the bioassays indicated that Army Creek and Pond were affected by the recovery well discharges, although the impacts were not readily discernible.

In March 1986, U.S. EPA and Weston conducted split sampling for bioassay and macrobenthos evaluations. Also well discharges were collected and composited on a weighted basis from the existing recovery wells for use in the bioassays.

Macrobenthos sampling results by the EPA and Weston were basically in agreement and concluded that the the low diversity of the pollution tolerant benthic species at all stations indicate degraded water quality within the watershed. The difference in diversity and composition of pollution tolerant species indicates that the macroinvertebrate community downstream of the pond is in better condition than the upstream station.

The bioassays were conducted using fathead minnows and Ceriodaphnia dubia. It was determined by EPA that recovery wells 9,28,29 and 31 exhibited chronic toxicity, while recovery wells 10,11,12,13,14 and 27 exhibited no chronic toxicity.

DNREC is currently drafting a National Pollution Discharge Elimination System (NPDES) permit for the discharge of water from the County recovery wells to Army Creek. At this point it seems likely that only water in the recovery wells exhibiting chronic toxicity (wells 9,28,29,31) will be required to be treated prior to discharge into Army Pond. Water from the wells which exhibit no chronic toxicity (wells 10,11,12,13,14,27) would be permitted to freely discharge into the pond.

A treatment alternative will not be chosen, at this time, because the final NPDES permit and its associated discharge limits has not been issued. In addition, the Delaware Sand and Gravel RI/FS has not been completed, therefore, we can not determine Delaware Sand and Gravel's contribution to the degradation of the groundwater, or the Army Creek and Pond at this time. It is our intention to combine the ultimate groundwater remedial actions at these two sites wherever possible. Also being deferred at this time is a decision on appropriate remedial measures for the sediments in Army Pond. Further analyses of the impacts on Army Pond is required to clarify what measures if any, are required.

This Record of Decision specifically deals with the selection of the source control alternative to prevent the generation of the leachate that contaminates the local groundwater. We are deferring our decision on groundwater treatment alternatives until the RI/FS at Delaware Sand and Gravel is complete and the NPDES permit is issued.

Environmental Assessment

The remedial investigations performed at the Army Creek Landfill Site revealed extensive groundwater contamination resulting from the generation of the leachate at the landfill. The groundwater and the surface water are contaminated with organic and inorganic priority pollutants, many of which exceed Water Quality Criteria for human health and aquatic life (Tables 1-4).

The major public health concern at the site is the contamination of the upper Potomac and Columbia aquifers. The major user of groundwater in the area is the Artesian Water Company, located near Llangollen Estates.

In 1973, New Castle County installed its groundwater recovery system to prevent the migration of contaminated plume towards Artesian's Wellfield. Due to the success of the groundwater recovery system operated by the County, along with the reduction in pumpage by Artesian Water Company, the contaminants emanating from Army Creek Landfill are not currently threatening drinking water supplies.

Army Creek and Army Creek Pond receive surface water runoff and recovery well discharges from the groundwater recovery system. However, Army Creek and Pond is restricted for public use, prior to its discharge to the Delaware River, one mile downstream. The effect of the creek on the Delaware river is expected to minimize due to dilution.

Surface water bioassays have indicated that the surface water system has been effected by the recovery well discharges, although the severity of the impacts on the aquatic life is not readily discernible.

ALTERNATIVE EVALUATION

The major objective for the remedial action to be taken at the Army Creek Landfill Site is to minimize further groundwater contamination by reducing the leachate generated by the landfill. The requirements of CERCLA Section 104, of CERCLA 420 U.S.C. § 9604, EPA's mandate to protect the public health and welfare and the environment, determine the goals and levels of response for the site.

In an effort to determine remedial alternatives for the subject site, feasible technologies were identified for consideration in a general response action table. Available technologies were then screened to eliminate all but the most definitive and feasible alternatives. This screening included: technical (site conditions or waste characteristics), environmental and public health, institutional, performance and cost criteria.

The technologies that have passed the technology screening process were examined further to identify remedial alternatives. Remedial alternatives were developed using best engineering judgment to select a technology or group of technologies that best addresses the problems existing at the site to protect public health, welfare and the environment. In an effort to provide a degree of flexibility in the final selection of a remedial action, alternatives covering a range of remedial action categories have been developed. These categories are described below:

1. No action: No-action alternatives could include monitoring activities.

2. Alternatives that meet the CERCLA goals of preventing or minimizing present or future migration of hazardous substances and protecting human health and the environment, but which do not attain all of the applicable or relevant standards. (This category may include an alternative that closely approaches but does not meet, the level of protection by the applicable or relevant standards.)

3. Alternatives that meet CERCLA goals and attain all applicable or relevant Federal public health and environmental standards, guidance, and advisories.

4. Alternatives that exceed all applicable or relevant Federal public health and environmental standards, guidance, and advisories.

5. Alternatives specifying offsite storage, destruction, treatment, or secure disposal of hazardous substances at a facility approved under the Resource Conservation and Recovery Act (RCRA). Such a facility must also be in compliance with all other applicable Environmental Protection Agency (EPA) standards.

The broad evaluation criteria selected were: technical feasibility, public health, environmental, institutional evaluation, and cost effectiveness. Within those criteria the following factors were considered.

- Technical Feasibility
  - °Performance
  - °Implementability
  - °Reliability

- Public Health Evaluation
  - °Reduction of Health Impacts

- Environmental Evaluation
  - °Reduction of environmental impacts
  - °Protection of Natural Resources

- Institutional Evaluation
  - °Legal requirements, institutional requirements
  - °Community Impacts

- Cost Effectiveness
  - °Capital Costs
  - °Operation and Maintenance Costs
  - °Present Worth Values
  - °Sensitivity Analysis

ANALYSIS OF REMEDIAL ALTERNATIVES

Alternate Technologies

Alternate technologies to recycle, destroy or treat the wastes were screened for use at this site. These technologies included incineration of the waste, recirculation and/or treatment of the leachate, and block displacement which consists of sealing the sides and/or bottom of the landfill by grout injection technique.

These technologies were not chosen for several reasons. The discontinuous nature of the subsurface soil conditions argued against the technical feasibility of grouting the sides or bottom.

Direct leachate recirculation or treatment was evaluated on a pilot scale in the landfill but clogging of the wells and low permeability of the refuse in some areas prevented further consideration. Only incineration technology was retained for further evaluation.

Note: Capital, Operation and Maintenance, and Present Worth Costs for all alternatives are found in Table 10.

Alternative No. 1 - No Action with Monitoring

The purpose of presenting a No Action Alternative is to provide a basis for comparison of existing conditions with the other proposed remedial alternatives. Under the No Action Alternative, no additional remedial activities would be taken and any current activities would be terminated at the Army Creek Landfill site. This would mean that the present hydrologic divide between the groundwater contaminant plume and the Artesian Water Company Wells, maintained by the recovery well system, would be eliminated.

This alternative includes a long-term monitoring program to provide information concerning contaminant presence and concentration. Groundwater monitoring would be performed between the landfill and the Artesian Water Company wells, and within the wellfield.

The primary public health concern of the No Action Alternative is the possible health risk resulting from the potential contamination of the downgradient production wells in the Artesian Water Company wellfield. Current production from these wells is approximately 2 million gallons a day (mgd), supplying the equivalent of 5,000 residences with drinking water. The effected population could increase, should the Artesian Llangollen Wellfield be shut down and the contaminants be drawn towards other wellfields in the area, including Artesian's Village, and Fairwinds wellfields located downgradient.

Of main concern is the attenuation of organic compounds found at concentrations exceeding drinking water criteria in nine of the twelve recovery wells. Table 1 lists the organic compounds found in the recovery wells, the maximum concentrations encountered, and the drinking water criteria. Under No Action, the contaminants would most likely be attenuated by dilution, dispersion and absorption prior to reaching a drinking water source. However, it is not known at what concentration these organics will persist in the groundwater. Therefore, a potential for human exposure by ingestion of organic compounds in concentrations above the drinking water criteria is associated with this alternative. This alternative would not provide protection to public health or the environment and contamination of groundwater through leaching of the contaminants would be expected to continue.

Common to All Other Alternatives

All of the source control alternatives discussed below would include a rigorous, initial sampling and analysis program. Both monitoring and recovery wells would be sampled for Hazardous Substance List (HSL) compounds in order to more precisely define the contaminants and their concentrations.

All of the source control alternatives include downgradient recovery wells to control the migration of the contaminant plume. A treatment alternative for the recovery well discharges can not be addressed at this time. The State of Delaware is in the process of issuing an NPDES permit that would identify the safe and appropriate levels for contaminants at the point of discharge into the Army Creek and Pond. Based on those limits, the treatment alternative will be determined at a later date.

A definite time period for phasing out the downgradient recovery well system cannot be established at this time for the following reasons:

- Groundwater quality for organics at the site can not be precisely defined with existing data.
- The total impact of the Delaware Sand and Gravel Landfill on the groundwater is not known at this time.
- The remedial actions to be taken at the Delaware Sand and Gravel Landfill are not known. These actions may affect the quality of groundwater at the Army Creek site.

The following methodology will be considered for phasing out the recovery well system:

The recovery well system will be evaluated in terms of both the flow system and water quality for a period of five years after the cap is installed or after the waste is excavated. If primary drinking water criteria levels are not met within this evaluation period, alternate concentration levels (ACL) will be considered. The ACLs will be based on an evaluation to define if sufficient attenuation will be achieved downgradient of the Army Creek Landfill, so that drinking water criteria levels will be met at any potential receptors. These ACLs will be applied at the recovery wells or the property boundary. When the ACLs are met, the recovery well system could be phased out.

Alternatives that include a cap may encroach on the 100 year floodplain at the south end of the site. The floodplain extends to approximately the ten foot contour. During design, detailed surveys and design evaluation will determine if any portion of the cap must extend to this area. Suitable measures including gabions or rip-rap may be used to protect the cap and minimize encroachment in the floodplain.

Alternative No. 2 - Downgradient Pumping

Alternative No. 2 consists of a series of downgradient pumping wells to recover contaminated groundwater and control its migration. In 1972, when it was discovered that leachate had entered the underlying confined aquifer in the Potomac Formation and had contaminated a nearby domestic well, Weston was retained by New Castle County to investigate the extent of the problem and propose potential solutions. Preliminary hydrogeologic investigations conducted by Weston indicated that the leachate had contaminated a substantial volume of the upper Potomac aquifer and that contaminated groundwater was moving in the

direction of the Artesian Water Company's Llangollen Wellfield in response to both the natural groundwater gradient and the pumping effects of the Artesian wellfield. The nearest Artesian Water Company well was located about 1,600 feet from the edge of the contaminant plume.

Based on preliminary hydrogeologic investigations, a contaminant recovery and monitoring program was designed and implemented in 1973 as an initial step towards an eventual solution to the problem. The recovery program was designed to achieve the following objectives:

- To control the migration of contaminants towards Artesian Water Company's wells and to contain them in an area closer to the landfill.
- To create a groundwater divide between the Artesian wellfield and the contaminated zone such that the groundwater flow in the contaminated zone could be reversed and the contaminated groundwater between the recovery wells and wellfield would move toward the Army Creek Landfill.
- To recover contaminated water and restore the aquifer water quality.
- To monitor the water quality and water levels in the area and evaluate the effectiveness of the recovery program.
- To develop feasible leachate treatment and disposal methods until some type of permanent solution to the problem was determined.

As a result, a large number of observation and recovery wells was constructed. While the observation wells were constructed in both the shallow Columbia sediments and the underlying Potomac aquifer, the recovery wells were constructed only in the contaminated zone of the upper Potomac aquifer, which is the aquifer source used by Artesian.

The initial recovery well system consisted of eleven recovery wells RW-1, 2,3,4,5,6 and wells 27,28,29,31 and 53 (Figure 3). In 1977, the data collected during the initial operation from 1973 to 1977 was evaluated. The following conclusions were made at that time based on the evaluation:

- The recovery wells have been successful in containment of the contaminated groundwater plume within the groundwater flow south of the Army Creek Landfill.
- A groundwater divide has been developed between the Artesian Water Company's wellfield and the contaminated zone of groundwater. The groundwater flow in the contaminated zone between the landfill and the Artesian wellfields has been reversed towards the recovery wells and the Army Creek Landfill.
- Recovery wells RW-1, RW-3, RW-4, and RW-5 continued to "pull back" the contaminants to as far as their present locations; these recovery wells could be phased out of the system in stages by reducing their pumping rates.

- It would be necessary to monitor the water quality in the vicinity of recovery wells RW-1, RW-3, RW-4 and RW-5 more frequently than usual when their pumping rates have been reduced. This would assure early detection of any deterioration in water quality caused by reduced pumping rates.

- It appears that most of the inorganic contaminants are discharged into the upper Potomac aquifer in an area of the landfill north of recovery wells 27, 28 and 29 and in the southwest corner of the landfill.

- The total pumping rate of the recovery wells was approximately 1.5 million gallons per day, which is about 7.5 times more than the average daily rate of potential leachate production. Leachate would be recovered more efficiently if the wells were located within and closer to the landfill.

- Incrustation has caused a significant problem requiring frequent rehabilitation of the recovery wells. To control the incrustation problem, the pumping rates of the existing recovery wells should be further reduced by about 50 percent.

- When RW-1, RW-3, RW-4 and RW-5 have been phased out of the recovery program, more recharge will be available for Artesian Water Company's wells.

It was therefore recommended that new wells RW-10, RW-11, RW-12, RW-13 and RW-14 be installed closer to the landfill such that leachate and contaminated groundwater could be recovered more efficiently. This was also recommended by the Round Table Conference in 1977.

In May 1982, the effectiveness of the modified downgradient pumping system was evaluated through a series of pump tests performed on the new recovery wells, RW-10, RW-11, RW-12, RW-13 and RW-14. The conclusions and recommendations generated as a result of the pump tests resulted in the phasing out of recovery wells RW-2, RW-3, RW-4, RW-5 and RW-6. The current downgradient pumping system includes RW-14, RW-13, RW-12,31,29,28,27, RW-1, RW-11, RW10, and RW-9 (Figure 3). The current system has maintained the groundwater divide necessary to intercept contaminated groundwater.

The clogging of well screens and discharge lines by iron precipitate is a continuous problem that is addressed through a regular program of well rehabilitation and pump repair. During the period of June 1982 through April 1983, at least one well was off-line for maintenance, repair or rehabilitation during any given month, with the exception of June 1982. Since the phasing out of wells with the porest performance, a biannual maintenance program has been established to treat and rehabilitate the twelve operating wells. Maintenance and replacement of parts have been performed as part of the maintenance program.

Since the recovery well system is already in place and operative, there is no implementation time necessary for this alternative.

Sampling and testing performed at the Artesian Water Company's wellfield and concentration gradient maps of the area have indicated that the downgradient pumping system along with controlled withdrawal by Artesian has been effective in containing the contaminated groundwater plume through the creation of a hydrologic divide between the landfill and the Artesian Water Company's wellfield. Alternative 2 has therefore been proven to have contained contaminated groundwater. By controlling the contaminated groundwater the pumping system has prevented the possible abandonment of the upper Potomac aquifer as a source of water supply in the production wellfields near the landfill and reduced the public health risk that could have resulted if the contaminated groundwater plume was not controlled.

Alternative 2 does not, however, address the source of leachate entering the Potomac aquifer or the pathways through which water enters the landfill resulting in leachate production. Precipitation infiltrating through the landfill surface and groundwater infiltration through the northwest side of the landfill from the Columbia aquifer will continue under this alternative. Therefore, leachate migration into the Columbia and upper Potomac aquifer will continue should Alternative 2 be implemented.

This alternative does not attain all applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

Alternative No. 3 - Downgradient Pumping and Landfill Capping

Alternative 3 consists of the downgradient pumping program evaluated under Alternative 2, and includes capping the landfill with a multi-layered cap.

The multi-layer cap system represents a recently developed cover technology that is gaining widespread use as an infiltration control strategy for waste containment or in-place closure. The multi-layer cap system performs the basic functions of minimizing infiltration into the waste site; directing and transmitting percolation and gas migration away from the site; and providing a final cover for the site and growth medium for vegetation. A typical multi-layer cap system, as shown on Figure 5, consists of the following three layers:

a) Uppersoil layer. A top soil and native soil layer, typically placed to a depth of about 12-24 inches. This layer serves to support vegetation, provide a cover for the drain layer, and divert surface runoff.

b) Middle drain layer. A graded layer of porous flow zone material (e.g., sand, gravel, geogrid) to act as a drainage medium. This layer is typically placed to a depth of about 18 inches.

c) Cap layer. A compacted layer of fine-grained soils of low permeability designed to divert infiltration that has percolated through the upper soil layer. This cap layer is typically placed to depths of about 18-24 inches.

The successful multi-layer cap system incorporates the use of low permeability materials to provide a surface seal over the contaminated area. A zone of high

permeability materials, such as graded gravel, aggregate, and drainage geotextiles, is typically placed over a cap layer to enhance lateral movement of water that percolates through the upper soil layer. The upper soil layer provides the followir

(a) A soil cover to promote runoff.

(b) A protective cover for the drain layer.

(c) A medium for growth of vegetative cover.

The vegetation not only stabilizes the cover system from possible damage due to water or wind erosion, but also contributes to moisture loss through evapotranspiration.

Several major advantages of the multi-layer cover system as compared to a standard native soil cover include the following:

(a) A protective soil layer is placed over the cap layer; the cap is not directly exposed to excessive damage due to weathering, cracking or root penetration.

(b) A drain layer serves to divert additional percolating water so it does not eventually migrate into the underlying waste material.

(c) Possible slumping of the topsoil and upper soil layers is minimized.

Calculations using hydrologic simulation modeling show that the multi-layered cover system can divert greater than 90 percent of the precipitation falling on the site. Since the cover is constructed of natural materials, it is expected to remain effective over the 30-year evaluation period.

Final design studies will be used to determine the material types and specifications for the number of layers and thickness of the final cap system. Any system installed will comply with the RCRA cap requirements.

Alternative 3 provides the same health benefits as Alternative 2 by containing the contaminant plume through the creation of a hydrologic divide between the landfill and the Artesian Water Company's wellfield by downgradient pumping. The recovery pumping program in place at the Army Creek Landfill has proven to have contained contaminated groundwater close to the landfill. By controlling the contaminant plume, the pumping system has prevented the possible abandonment of the upper Potomac aquifer as a source of water supply in the production wellfields near the landfill.

This alternative attains all applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

Alternative No. 4 - Downgradient Pumping, Landfill Capping, and Upgradient Controls

A. Non-phased Approach - The non-phased approach to Alternative 4 would include the continuation of the downgradient pumping program and the simultaneous

construction of the final cap system and the upgradient groundwater controls (Figure 6). This approach to Alternative 4 provides additional immediate measures to further mitigate the environmental impacts of the landfill as compared to Alternative 3. The upgradient controls would intercept and significantly reduce the groundwater entering the landfill along the northwestern side, thus reducing the potential volume of leachate produced. The flow of groundwater into the landfill along the northwestern side has been estimated at 25,000 gpd as compared to 4,000 gpd of precipitation infiltration.

B. Phased Approach - The phased approach to Alternative 4 involves two phases. Phase 1 would include installation of the final cap system with continuation of the downgradient pumping system. The effect on the groundwater quality as a result of capping the landfill would then be monitored and assessed prior to initiating Phase 2 upgradient controls. It is possible that although a significantly greater volume of groundwater passes through the site than does precipitation, the refuse that comes in contact with the groundwater has already had much of the contamination leached after almost seventeen years in a saturated state. Monitoring has also shown that the groundwater table elevations have dropped over the past twelve years due to the additional pumping, resulting in a lesser quantity of refuse that is saturated. Precipitation, on the other hand, percolates through the entire refuse stratum, allowing for more contact with a greater volume of landfill material. Following an evaluation period of 5 years after the cap is installed, the need for upgradient groundwater controls to reduce leachate production would be determined. This determination would be based on the evaluation of the monitoring well water levels, pumping rates and water quality.

Both the phased and non-phased approaches include surface management measures and gas venting as part of the construction of the cap system.

The technical evaluation of the downgradient pumping program has been performed under Alternative 2, and the evaluation of the multi-layer cap system under Alternative 3. Final design analysis will be used to determine the material types and specifications for the number of layers and thickness of the final cap system. The analysis for this alternative will therefore concentrate on evaluating the upgradient controls. An upgradient pumping network is used here for evaluation purposes only. The final upgradient control (pumping or trench) would be determined during the design phase. It is anticipated that less pumping, both in quantity and duration, by the downgradient recovery well system would be required as a result of capping the landfill. Upgradient controls should further hasten groundwater cleansing, reducing the time the downgradient system has to be operated.

The arrangement and number of recovery wells necessary to prevent the lateral inflow of groundwater into the Army Creek Landfill would be contingent upon several of the following factors; the volume of inflowing water, the depth to which the water table must be lowered, and the ability of the Columbia aquifer to transmit water.

To intercept the inflowing groundwater and lower the water table within the landfill, Weston determined that five recovery wells, spaced at 320-foot intervals, would be needed. The wells could be located directly south of the railroad tracks along the northwestern boundary of the landfill (Figure 3). To ensure maximum drainage from the Columbia aquifer, the depth of the wells should extend to the base of the aquifer (25 to 30 feet).

An evaluation of various pumping rates estimated that a discharge rate of 20 gpm per well would provide maximum drainage of the Columbia aquifer without exceeding the critical well drawdown limits. The pumping rate of 20 gallons per minute(gpm) at each of the five wells would remove approximately 144,000 gpd of groundwater, creating a hydrologic drain for the groundwater enroute to the landfill. The drawdown influence from the pumping wells would lower the water table within the refuse. Upgradient pumping would essentially dewater a major portion of the refuse, leaving only a fraction of the total waste volume saturated near the base of the Columbia Formation.

The water level in Army Creek could potentially impact the dewatering influences of the upgradient wells. If the cumulative drawdowns from the five recovery wells lowers the water table below the water level of Army Creek, then surface water flow into the Columbia aquifer could be induced. This would eventually create a steady-state condition between the water levels in the wells and the stage of the stream. At this time, the variation in the elevation of the surface water in Army Creek is unknown, and the effect of the stream on the maximum water table drawdowns cannot be determined.

Alternative 4 provides the same health benefits as Alternatives 2 and 3 by containing the contaminant plume through the creation of a hydrologic divide between the landfill and the Artesian Water Company's wellfield by downgradient pumping. Alternative 4 provides further measures to mitigate the environmental impacts remaining after the implementation of the downgradient pumping and landfill capping included in Alternative 3. Under the non-phased approach to Alternative 4, upgradient controls will be installed at the same time the landfill is capped. Both pathways of infiltration into the landfill would, therefore, immediately be addressed. Potential leachate production should be significantly reduced as a result of these actions. It is therefore anticipated that groundwater cleansing would be further hastened under Alternative 4.

The phased approach would allow for a period of monitoring and assessment of the effectiveness of capping the landfill on groundwater quality. Following an evaluation period of 5 years after the cap is installed, the need for additional measures to reduce leachate production would be determined. This decision would be based on an evaluation of water levels and water quality at the Army Creek Landfill.

This alternative attains all applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

Alternative 5 - Downgradient Pumping, Partial Removal and Landfill Capping

Alternative 5 consists of the downgradient recovery well system also included

in Alternatives 3 and 4, the excavation of the landfill refuse in the western section, and movement of the excavated refuse on the eastern section. The eastern section would then be graded and capped with a multi-layered cap system, and the western section backfilled with clean fill material, graded to drain surface run-off and vegetated. Erosion and run-off controls would be established in excavated and fill areas. The saturated refuse in the western section would require "dewatering" or draining as it is excavated and would be mixed with dryer refuse to be placed and compacted on the eastern section of the landfill. A combination of draining/pumping of free liquids from the saturated refuse and upgradient controls would be required for the dewatering process. Figure 7 provides a graphical presentation of Alternative 5.

This alternative will remove one of the sources of contamination of the Columbia aquifer and subsequently the upper Potomac aquifer by the excavation of the western section of the landfill. Field information suggests that groundwater is infiltrating the refuse laterally in this section of the landfill.

This alternative also addresses the precipitation infiltration through the removal and redeposition of refuse to the eastern section of the landfill which would then be capped with a multi-layered cap system. The multi-layered cap system was evaluated in Alternative 3. Alternative 5 would be effective in addressing the pathways of infiltration and reducing the potential volume of leachate produced from an estimated 29,000 gpd (25,000 gpd groundwater infiltration plus 4,000 gal/day of precipitation infiltration) to an estimated 200 gpd (precipitation infiltration through multi-layered cap system). Source removal would provide an effective long-term solution to groundwater contamination at the site. The useful life of the multi-layered cap system would depend on the establishment of a maintenance program that would maintain a proper vegetated cover and integrity of the cap. A properly constructed and maintained cap should last through the 30-year evaluation period.

Once the vegetation on the multi-layered cap system is established it would require routine regular maintenance. The entire vegetated area should be mowed once or twice a year to minimize the potential for growth of deep-rooted vegetation. The surface cap on the eastern section should be periodically inspected to assure continued integrity of the capping system. Cracking, erosion damage, and differential settlement damage would require repairs.

Two of the major concerns resulting from the excavation of the western section of the existing landfill include the following:

- Dewatering of the western section would be required before the saturated refuse is excavated from below the water table. Upgradient controls similar to the system outlined under Alternative 4 can be used to lower the water table below the refuse. Complete dewatering may include the construction of drains and sump controls, but it is anticipated that most of the free liquid would be removed by the upgradient controls. The discharge from the upgradient controls could possibly require treatment. Since the duration of pumping (if used) will be short-term (time required to excavate the western section), the most cost effective treatment

option could possibly be discharge to the local waste treatment facility (Wilmington Waste Water Treatment Plant).

- A potential slope stability problem could result between the eastern section and the western section as excavation of the western section resulted in deep cuts into landfill refuse. The excavation should proceed in an "area" type manner to minimize deep cuts and possible stability problems. Final side shapes after backfilling in the eastern section should be limited to a maximum ratio of 3 horizontal to 1 vertical (3:1) to ensure slope stability.

Excavation of the saturated refuse would be accomplished using either backhoes or draglines working from the top of the working face. If a pocket of non-refuse or potentially hazardous wastes has been identified, special excavation and handling procedures would be initiated.

All of the refuse, with the possible exception of waste requiring special handling, would be loaded onto dump trucks. These vehicles could then haul the refuse on a temporary access road along the north side of the landfill running parallel to the existing railroad. Free liquid from the transportation of the refuse would therefore be contained within the existing landfill area. Extensive odor control would be necessary within and around the perimeter of the excavation site for the dump trucks.

After the western section had been completely excavated and backfilled with a clean soil fill, the eastern section would be prepared for the final capping. The cap would be placed over the intermediate soil cover and utilize a multi-layer design. The multi-layer cap system would significantly reduce precipitation infiltration. Erosion and sedimentation controls would be initiated until a proper vegetated cover is established. Gas venting and surface management measures will be installed during the construction of the cap system.

While Alternative No. 5 represents a potential safety risk to the construction workers, due to the unknown types of wastes and conditions which would be encountered during excavation, proper safety protocol would reduce the risk.

Alternative 5 provides the same health benefits as Alternatives 2, 3, and 4 by containing the contaminant plume through the creation of a hydrologic divide between the landfill and the Artesian Water Company's wellfield by the existing downgradient pumping program. Alternative 5 provides basically the same environmental benefits as Alternative 4 but addresses the groundwater infiltration condition in the western portion of the landfill by eliminating the source of leachate generation through total removal of the refuse in the western section. Groundwater cleansing would be hastened by the elimination of the source of contamination. Capping the eastern section with a multi-layer cap would significantly reduce precipitation infiltration which would further hasten groundwater cleansing.

During excavation, odor and vector problems would likely occur in addition to the need to handle draining water from saturated refuse. Leachate pumped during dewatering operations before the saturated refuse is excavated would need to be collected and treated.

This alternative attains all applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

Alternative 6 - On-site Incineration and Downgradient Pumping

This alternative consists of the construction of an incinerator and power generator facility adjacent to the subject site, excavating and incinerating the waste, and backfilling the ash residue on-site. In order for this alternative to be feasible, the excavated landfill wastes at the site would need to be mixed with raw-solid waste from nearby communities or other fuel to produce a combustible mixture. Otherwise, the fuel requirements for burning the wet waste would be very excessive. Excavation of the saturated material would require dewatering. This could be achieved by upgradient pumping or pumping directly from the excavated area. The discharge from the dewatering operation could require treatment.

This alternative would include continued downgradient pumping to assure that contaminated groundwater did not reach the Artesian Water Company's wellfield. A long-term groundwater monitoring program would determine when the downgradient recovery system could phased out after the landfill had been removed and incinerated.

Alternative 6 would provides basically the same public health and environmental benefits as Alternatives 4 and 5 through downgradient pumping and removal of the source by excavation and incineration. Dry refuse or other fuel would need to be transported to the site and mixed with the saturated waste to make it burnable. Air pollution control devices required under RCRA would reduce the release of contaminants into the air. Incinerator ash and residue would be backfilled on-site only in areas above the groundwater table and eventually capped. Dust, odor and drainage of liquids from the saturated waste are problems associated with the excavation of landfill refuse. Other environmental and health concerns would be associated with the transport of dry refuse to the Army Creek Landfill site. These concerns include noise and dust from transportation and vector problems. Measures such as vector control and site access routing, would be initiated to mitigate these problems. Construction activities during excavation could affect wetlands habitats through noise, surface water diversion practices and dust. Drainage could also have an effect, if not controlled.

On-site incineration would be required to meet the technical requirements of RCRA. In addition to RCRA requirements, the remedy would need to comply with other applicable State and Federal requirements but would not need a permit. A monitoring program would also be a mandatory part of the incineration process. Significant public opposition could be expected to this alternative.

This alternative attains and/or exceeds applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

Alternative 7 - Off-site Disposal by Landfilling at an Approved Site and Downgradient Pumping

This alternative consists of completely removing the landfilled waste by

standard excavation methods and disposing of the waste in an approved off-site facility. Upgradient pumping has also been included for the anticipated dewatering of the saturated material in the bottom of the western part of the landfill prior to excavation. The landfill area would be backfilled, following complete excavation of the waste material. This alternative would eliminate a source of leachate generation (refuse) and thus eliminate the addition of contaminants to the groundwater.

This alternative includes a downgradient pumping program. Monitoring of the recovery system will determine when the system can be phased out after complete removal of the landfilled wastes.

Alternative 7 would provide basically the same public health and environmental benefits as Alternatives 4, 5, and 6 through downgradient pumping and the complete removal of the source of contamination by excavation and disposal in an approved off-site landfill facility. These actions would prevent direct human exposure and accelerate groundwater cleansing as do Alternatives 4, 5, and 6. Dust, odor, and noise problems would arise from the excavation and hauling actions contained in this alternative. The off-site facility would need to be a RCRA permitted landfill to assure that potential environmental impacts at the new site are minimized.

Commercial disposal facilities must meet stringent analytical, RCRA, and State permitting and compliance standards. Using off-site facilities also would require that the Department of Transportation requirements are met. Opposition could occur from the State receiving this large quantity of waste (approximately 2,000,000 cubic yards). Off-site facilities could also be reluctant to accept this large quantity of waste.

This alternative attains and/or exceeds all applicable and relevant public health and environmental standards as defined by CERCLA and RCRA.

RECOMMENDED ACTION (Table 10)

Section 300.68 (j) of the National Contingency Plan (NCP) states that the appropriate extent of remedy shall be determined by the lead agency's selection of the remedial alternative which the agency determines is cost-effective (i.e., the lowest cost alternative that is technologically feasible and reliable) and which effectively mitigates and minimizes damage to, and provides adequate protection of public health, welfare, or the environment. Based on our evaluation of the cost effectiveness of each of the proposed alternatives, of the comments received from the public, and information received from the Delaware Department of Natural Resources and Environmental Control, we recommend that the phased approach Alternative 4B be implemented at the Army Creek Landfill Site.

This alternative includes downgradient pumping with monitoring, landfill capping and possibly upgradient controls. This alternative will reduce the public health risk by possibly containing the contaminant plume through the downgradient recovery system. This alternative will also control precipitation infiltration through the landfill surface with a multi-layered cap. Groundwater infiltration through the northwest side of the landfill from the Columbia

aquifer will be controlled by upgradient measures; if necessary. Leachate migration into the Columbia and upper Potomac aquifers will be reduced. The upgradient controls (pumping or an interception trench) may be installed following an evaluation period of up to 5 years after the cap is installed. This decision would be based on an evaluation of water levels and water quality at the Army Creek Landfill. An additional component of this alternative is a well monitoring program.

At this time, tne selection of a groundwater treatment alternative has not been made and will be the subject of a future decision document. In particular this decision has been delayed because the final NPDES permit has not been issued and the Delaware Sand and Gravel RI/FS has not been completed. It is EPA's intention to combine the remedial actions at both sites where possible and cost-effective. Also being deferred at this time is a decision on appropriate remedial measures for sediments in Army Pond, that decision will be made at the same time as groundwater treatment is considered and after further analysis is accomplished regarding the actual impacts on Army Pond.

Operation and Maintenance

At least, quarterly inspection and maintenance will be required during the operation of the downgradient and upgradient controls. Wells will be inspected and maintained to insure their continual functioning.

Maintenance of the multi-layered cap will be required to ensure that the cap is functioning properly in preventing the infiltration of stormwater into the landfill. Vegetation loss, erosion, cracking or other cap disturbances will be corrected.

Consistency with Other Environmental Laws

Alternatives were examined in light of relevant Federal, state and local environmental program requirements and in light of all RCRA and CERCLA requirements for the closure of hazardous waste landfills and for disposal of excavated contaminants in offsite hazardous waste facilities, including landfills and incinerators.

The recommended action meets all applicable and relevant public health and standards as defined by RCRA and CERCLA.

Evaluation of Alternatives Not Selected (Table 11)

The No-Action Alternative No. 1 with monitoring was not selected since it would not control the source of contamination and would allow further degradation of groundwater. Implementation of the No-Action alternative would mean that the present hydrologic divide between the Army Creek Landfill site and Artesian Water Company's production wells would no longer exist. Therefore, a potential for human exposure by ingestion of organic and inorganic compounds in concentrations above the drinking water criteria would exist. This alternative does not provide protection to public health and the environment.

Alternative No. 2 involves downgradient pumping with monitoring. Although this alternative would reduce the public health risk by containing the contaminant plume through pumping, it would not, however, address the source of leachate entering the Potomac aquifer or the pathways in which water enters the landfill resulting in leachate production. Precipitation infiltration though the landfill surface and groundwater infiltration through the northwest side of the landfill from the Columbia aquifer would continue under this alternative. Therefore, leachate migration into the Columbia and upper Potomac aquifers would continue for Alternative No. 2.

Alternative No. 3 would involve downgradient pumping with monitoring and landfill capping. Although this alternative would reduce the public health risk by containing the contaminant plume through pumping and control precipitation infiltration through the landfill surface, it would not address groundwater infiltration through the northwest side of the landfill from the Columbia aquifer. Therefore, leachate migration into the Columbia and upper Potomac aquifers would continue for Alternative No. 3.

Alternative No. 5 would involve excavation of the landfill refuse in the western section, and disposal of the refuse on the eastern section, downgradient pumping with monitoring and capping. Alternative No. 5 would address the groundwater infiltration condition in the western portion by eliminating the source of leachate generation through total removal of the refuse in the western section of the landfill. This alternative was rejected because it provides the same benefits as Alternative No. 4, but costs twice as much ($37,930,000 vs. $15,290,000), and would be more difficult to implement.

Alternative 6 would involve on-site incineration and downgradient pumping. This alternative would provide basically the same public health and environmental benefits as Alternative 4 through downgradient pumping and removal of the source by excavations and incineration. This alternative was rejected because it would provides the same benefits as Alternative No. 4, but would cost 7 times ($108 million vs. $15,290,000) as much and would be more difficult to implement.

Alternative 7 would involve the complete removal of the landfill and downgradient pumping and monitoring. This alternative would provide basically the same public health and environmental benefits as Alternative 4 through downgradient pumping and removal of the source. This alternative was rejected, because it would provides the same benefits as Alternative 4, but costs 15 times as much ($243,000,000 vs. $15,290,000) and would be more difficult to implement.

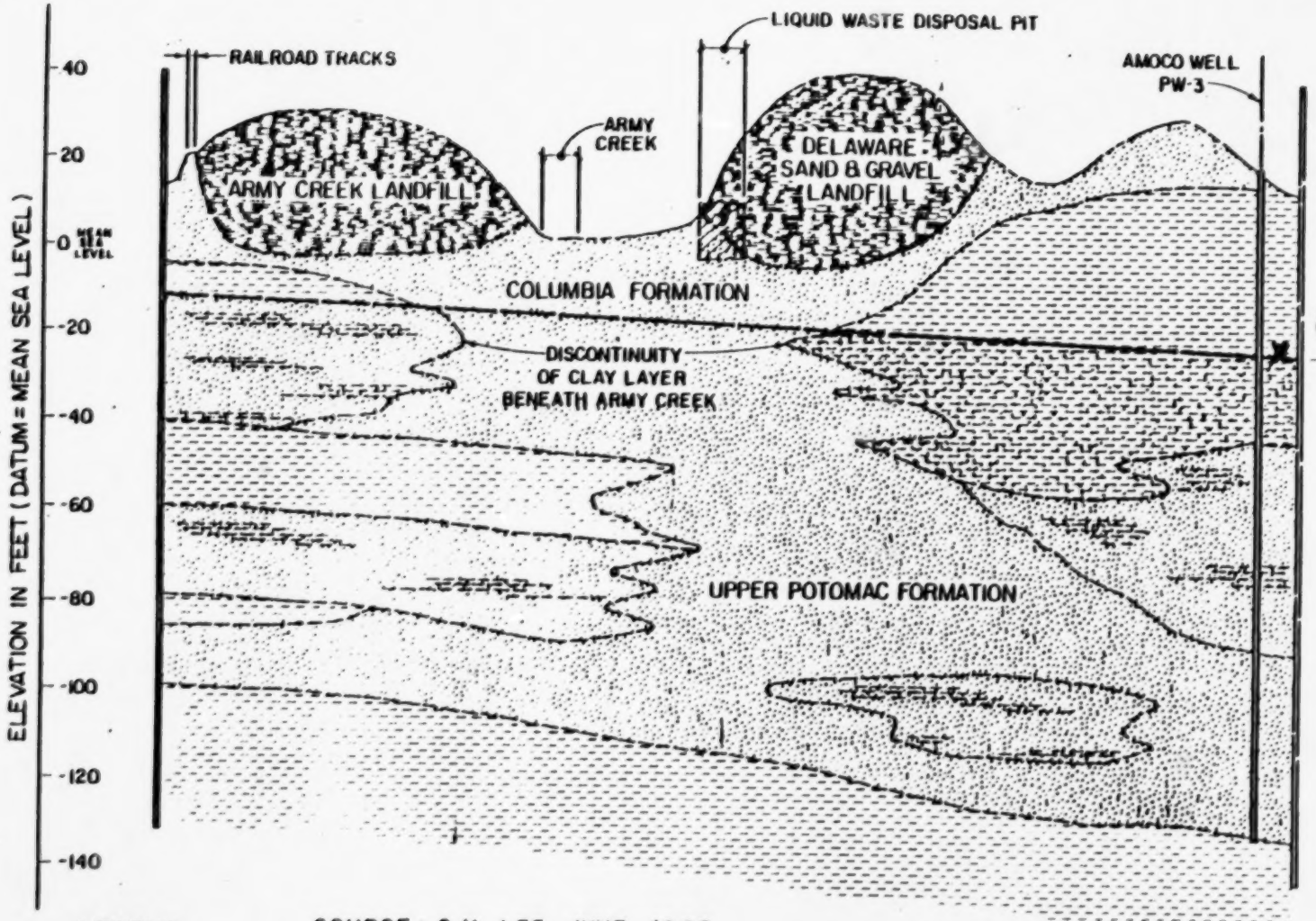
SE MAP IS A PORTION OF THE U.S.G.S. WILMINGTON SOUTH, DEL.-N.J. ADRANGLE (7.5 MINUTE SERIES, 1967) CONTOUR INTERVAL = 10'

FIGURE 1

LOCATION OF ARMY CREEK LANDFILL
NEW CASTLE COUNTY, DELAWARE

SCALE: 1" = 2000'

NUS CORPORATION



LEGEND

- SAND
- SAND WITH CLAY
- CLAY
- CLAY WITH SAND
- LANDFILL

SOURCE : C. K. LEE , JUNE , 1982

HYDROGEOLOGIC SECTION A-A
ARMY CREEK LANDFILL
NEW CASTLE COUNTY, DEL

HORIZONTAL SCALE: 1" ≈ 500'
NOT TO VERTICAL SCALE

FIGURE 2

NUS CORPORATION

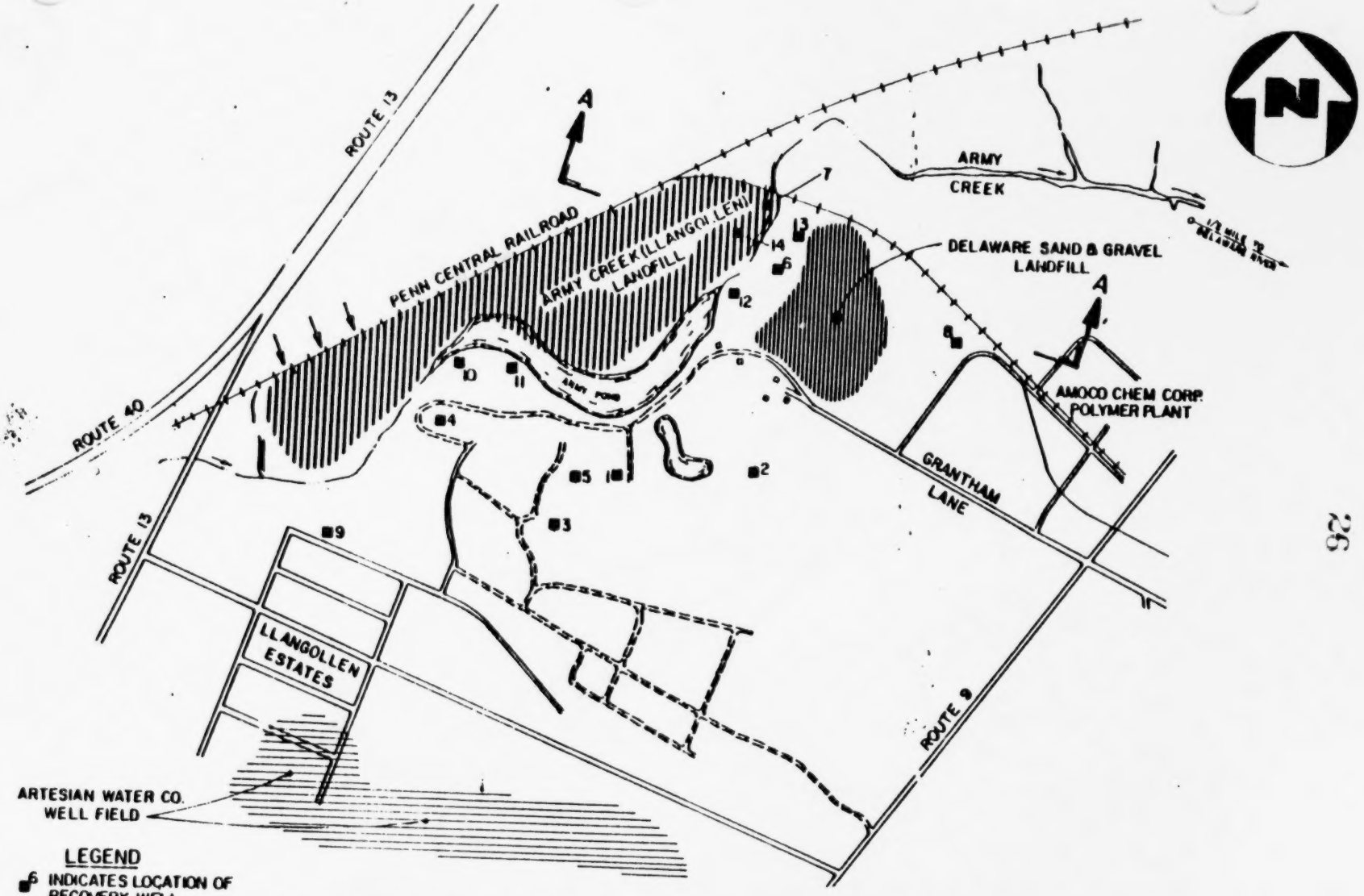


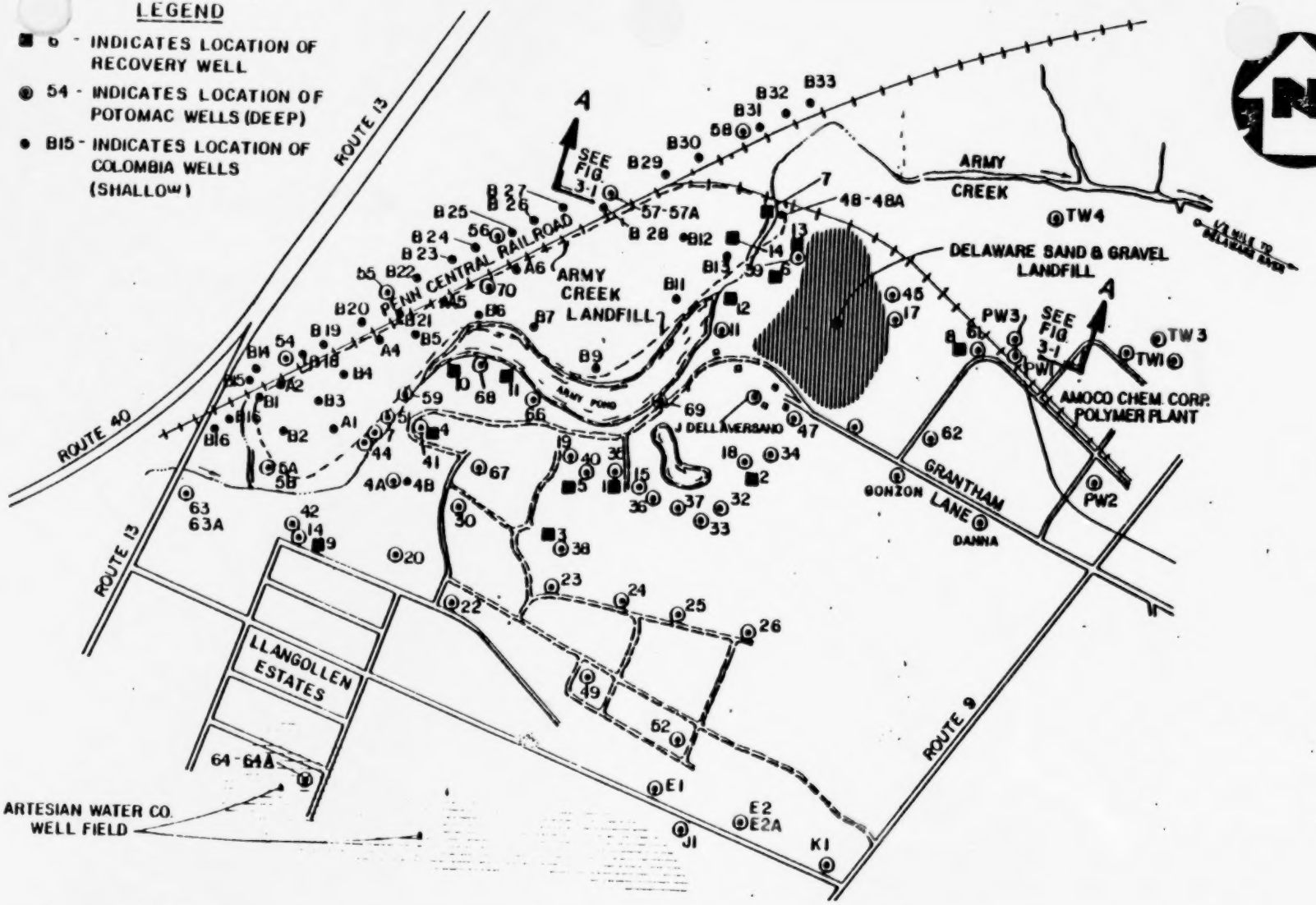
FIGURE 3

ARMY CREEK LANDFILL - SITE SKETCH

NEW CASTLE COUNTY, DELAWARE

SCALE: 1" = 1000'

NUS CORPORATION



ARMY CREEK LANDFILL - NEW CASTLE COUNTY, DELAWARE

LOCATION OF MONITORING, PRODUCTION AND RECOVERY WELLS

SCALE: 1" = 1000'

NUS CORPORATION

FIGURE 4

TABLE 1

ORGANIC COMPOUNDS IN RECOVERY WELLS
EXCEEDING DRINKING WATER CRITERIA*

Well	Parameter	Max. Conc. (ug/l)	Criteria (ug/l)
RW-1	Benzene	12.0	5.0[a]
	1,2-dichloropropane	40.6	6.0[b]
	Methylene Chloride	32.0	0.19[c]
RW-10	2,4-dinitrotoluene	44.0	0.11[d]
	N-nitrosodimethylamine	<10.0	0.00014[d]
	1,2-dichloroethane	51.0	5.0[a]
RW-11	Benzene	<10.0	5.0[a]
RW-12	Benzene	10.3	5.0[a]
	1,2-dichloropropane	25.1	6.0[b]
	Methylene Chloride	21.2	0.19[c]
	2,4,6-trichlorophenol	3.0	1.8[e]
	Bis(2-chloroethyl)ether	<10.0	0.03[d]
RW-13	1,2-dichloropropane	26.8	6.0[b]
	Methylene Chloride	21.3	0.19[c]
	Bix(2-chloroethyl)ether	46.0	0.03[d]
	Benzene	37.0	5.0[a]
RW-14	Bis(2-chloroethyl)ether	<10.0	0.03[d]
	2,4-dinitrotoluene	38.0	0.11[d]
28	Benzene	40.0	5.0[a]
29	Benzene	45.0	5.0[a]
31	Benzene	150.0	5.0[a]
	Methylene Chloride	16.3	0.19[c]
	Chlorodibromomethane	19.2	0.19[c]
	2,4-dinitrotoluene	116.0	0.11[d]

* = All laboratories (1983-1985)

a = Proposed Primary MCL (EPA, 13 November 1985)

b = Proposed RMCL (EPA, 13 November 1985)

c = Water Quality Criteria for Human Health (Fish and Drinking Water); concentration of total halomethanes (CWA)

d = Water Quality Criteria for Human Health - Fish and Drinking Water (CWA)

e Water Quality Criteria for Human Health - Adjusted for Drinking Water (CWA)

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TABLE 2

Army Creek Landfill
New Castle, Delaware
Ground Water Quality 1985*

Total Concentration (mg/L)	Well 54 Upgradient	Well 56 Upgradient	Well 21 Downgradient	Well 26 Downgradient	Drinking Water Criteria
Antimony	<0.010	<0.010	<0.010	<0.010	0.146[a]
Arsenic	<0.002	<0.002	<0.002	<0.002	0.050[b]
Beryllium	<0.0005	<0.0005	<0.0005	<0.0005	0.0000039[c]
Cadmium	0.0006	0.001	0.0006	0.0015	0.010[b]
Chromium **	0.0216	0.0151	0.0136	0.0288	0.050[b]
Copper	0.0048	0.0133	0.0032	0.0104	1.3[f]
Lead	0.0101	0.0089	0.0068	0.0063	0.050[b]
Mercury	0.0072	0.0006	0.0002	0.0001	0.002[b]
Nickel	0.050	0.070	0.060	0.050	0.0154[c]
Selenium	<0.050	<0.050	<0.050	<0.050	0.010[b]
Silver	<0.0005	<0.0005	<0.0005	0.0018	0.050[b]
Thallium	<0.002	<0.002	<0.002	<0.002	0.0178[c]
Zinc	0.010	0.010	0.030	0.050	5.0[d]
Iron	2.540	0.220	1.160	1.650	0.3[e]
Manganese	0.160	0.060	0.040	0.080	0.050[e]

* - Analyzed by New Castle County Laboratory
** - Containers probable source of chromium (NO, leaches chromium from polyurethane
a - Water Quality Criteria for Human Health - Fish and Drinking Water (CWA)
b - Interim Primary MCL (EPA, 13 November 1985)
c - Water Quality Criteria for Human Health - Adjusted for Drinking Water Only (CWA)
d - Water Quality Criteria - Organoleptic - Fish and Drinking Water (CWA)
e - Secondary MCL
f - Proposed MCL (EPA, 13 November 1985)

TABLE 3

ARMY CREEK LANDFILL
NEW CASTLE, DELAWARE

RECOVERY WELL INORGANIC WATER QUALITY 1981*

Total Concentration (mg/l)	RW-1	RW-3	RW-4	RW-6	RW-9	RW-10	RW-11	RW-12	RW-13	RW-14	27	28	29	31	Drinking Water Criteria	Surface Water Criteria
Antimony	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	0.0064	<0.001	0.0048	<0.001	0.0061	<0.005	<0.001	0.146[a]	1.6[c*]
Arsenic	0.0092	0.010	0.0198	0.0067	<0.001	0.014	0.0246	<0.001	0.0034	<0.0003	0.0206	0.0024	<0.001	0.005	0.050[b]	0.040[c]
Beryllium	<0.0005	<0.0005	<0.0005	<0.0005	0.0052	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0004	0.0012	<0.0005	0.0000039[d]	0.0053[c*]
Cadmium	0.0056	0.0214	0.004	0.006	0.0009	0.0054	0.0051	0.0035	0.0021	0.0018	0.0038	0.0011	0.0009	0.0028	0.010[b]	0.10[e]
Chromium**	<0.005	0.0084	0.0099	0.0147	0.0373	0.0123	0.0196	0.0185	<0.005	<0.005	<0.005	0.0733	0.0847	<0.005	0.050[b]	0.150[e]
Copper	0.0089	0.0243	0.0084	0.0104	0.0095	0.0105	0.0132	0.0142	0.0144	0.009	0.0197	0.0344	0.008	0.026	1.3[h]	0.50[e]
Lead	0.0053	0.0037	<0.001	0.0084	0.0034	0.0055	0.0042	0.0017	0.0033	0.0034	0.0051	0.003	0.005	0.0131	0.050[b]	0.150[e]
Mercury	0.0018	0.0016	0.0016	0.0047	NR	0.0007	0.0071	0.0028	0.0023	0.003	0.004	NR	NR	0.0011	0.002[b]	0.005[e]
Nickel	0.310	0.080	0.250	0.120	0.016	0.060	0.170	0.090	0.250	0.050	0.190	0.0029	0.0023	0.240	0.0154[d]	1.0[e]
Selenium	0.0091	0.0061	0.0151	<0.002	<0.200	0.0079	0.0209	<0.002	<0.002	<0.002	0.0267	<0.200	<0.200	<0.002	0.010[b]	0.020[e]
Silver	0.0029	0.0027	0.0038	0.0013	0.0003	0.0088	0.0049	0.0037	0.0039	0.0004	0.0086	0.0018	0.0005	0.0012	0.050[b]	0.10[e]
Thallium	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	0.0067	0.001	0.0062	0.0033	0.005	0.0065	<0.005	<0.001	0.0178[d]	0.04[c*]
Zinc	0.020	0.030	0.010	0.040	<0.010	0.030	0.010	0.010	0.010	0.020	0.020	0.020	0.010	0.010	5.0[f]	1.0[e]
Iron	4.30	6.60	53.0	11.2	21.7	5.68	6.90	16.8	11.30	8.0	16.6	47.6	40.2	10.4	0.3[g]	2.0[e]
Manganese	0.95	0.52	1.08	1.35	1.3	0.48	0.51	1.00	0.70	0.79	0.67	1.59	1.56	1.21	0.50[g]	--

* - Analyzed by New Castle County Laboratory

** - Containers probable source of chromium; HNO_3 leaches chromium from polymethane

NR - No Results
a = Water Quality Criteria for Human Health - Fish and Drinking Water (CWA)
B = Interim Primary MCL (EPA, 13 November 1985)
c = Criteria after Freshwater Aquatic Life (CWA)
d = Water Quality for Human Health - Adjusted for Drinking Water Only (CWA)
e = State of Delaware Water Quality Criteria for Discharges (1983)
f = Water Quality Criteria; Organoleptic - Fish and Drinking Water (CWA)
g = Secondary MCL
h = Proposed MCL (EPA, 13 November 1985)
* = Apparent Threshold Limit Values (CWA)

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TABLE 4

Army Creek Landfill
New Castle, Delaware
Ground Water Quality
EPA September 1984 Sampling

Total Concentration (mg/l)	Well 54 Upgradient	Well 56 Upgradient	Well 24 Downgradient	Well 26 Downgradient	Well 30 Downgradient	RW-9 Recovery	RW-13 Recovery	Well 29 Recovery	Drinking Water Criteria	Surface Water Criteria
Antimony	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	0.146[a*]	1.6[c*]
Arsenic	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.050[b]	0.04[c]
Beryllium	0.020	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.000003[g,i]	0.0053[c*]
Cadmium	<0.005	0.0066	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.010[b]	0.1[e]
Chromium	0.258	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.05[b]	0.150[e]
Copper	0.490	0.090	<0.050	0.190	<0.050	<0.050	<0.050	<0.050	1.3[g]	0.5[e]
Lead	0.190	0.021	0.018	0.770	0.019	<0.002	0.010	<0.002	0.050[b]	0.150[e]
Mercury**	0.022	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.002	0.002[b]	0.005[e]
Nickel	0.156	<0.050	<0.050	0.083	<0.050	<0.050	<0.050	<0.050	0.0154[d]	1.0[e]
Selenium	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	0.010[b]	0.02[e]
Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05[b]	0.1[e]
Thallium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0178[d]	0.04[c*]
Zinc	0.427	0.093	0.064	0.188	0.056	<0.050	<0.050	<0.050	5.0[f]	1.0[e]

** Analyzed beyond the holding time

a = Toxicity value for protection of potable water supplies
b = Primary Drinking Water Standard
c = Secondary Drinking Water Standard
d = Water Quality Criteria for Human Health - Adjusted for Drinking Water Only (CWA)
e = State of Delaware Water Quality Criteria For Discharges (CWA)
f = Water Quality Criteria, Organoleptic - Fish and Drinking Water (CWA)
g = Proposed MCL (EPA, 13 November 1985)
* = Apparent Threshold Limit Values (CWA)

TABLE 5

Army Creek Landfill
New Castle, Delaware
Army Creek and Pond Water Quality
EPA/FIT Sampling 9-11 November 1981
Organic Concentrations (ug/l)

Station	Pyrene	PCB-1248	Fluoranthene	Bis (2-ethylhexyl) Phthalate	Di-n-butyl Phthalate	Benzo (a) anthracene	Chrysene	Anthracene	Phenanthrene	Benzene (a) Pyrene	Benzo (b) Fluoranthene	Benzo (k) Fluoranthene	Benzo (ghi) perylene
I (Rt. 13)	ND	ND	ND	*	*	ND	ND	ND	ND	ND	ND	ND	ND
II (RR tracks)	*	ND	*	*	*	*	*	*	*	ND	ND	ND	ND
III (nr. RW-9) (discharge)	*	ND	*	*	*	*	*	*	*	ND	ND	ND	ND
IV (nr. RW-4) (discharge)	*	ND	*	*	*	*	*	*	*	*	*	*	*
V (nr. Amoco)	ND	350.	*	*	*	ND	ND	*	*	ND	ND	ND	ND

ND = Not Detected

* Indicates chemical present in sample

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TABLE 6

Army Creek Landfill
New Castle, Delaware
Army Creek and Pond Water Quality
Inorganic Concentrations (mg/l)
BC:/FIT Sampling 9-11 November 1981

Total Conc.	Station I (Rt.13)	Station II (RR tracks)	Station III (nr. RW-9 discharge)	Station IV (nr. RW-4 discharge)	Station V (nr. Amoco)	Surface Water Criteria
Aluminum	0.150	0.400	0.300	0.150	0.400	—
Chromium	<0.010	<0.010	<0.010	<0.010	<0.010	0.021[b]
Barium	0.060	0.170	0.270	0.090	0.210	—
Beryllium	<0.002	<0.002	<0.002	<0.002	<0.002	0.0053[b]
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	0.000025[c]
Cobalt	<0.010	0.010	0.020	<0.010	0.050	0.022[a]
Copper	<0.020	<0.020	<0.020	<0.020	0.200	1.000[b]
Iron	1.760	2.160	25.000	0.880	167.000	
Lead	<0.040	<0.040	<0.040	<0.040	<0.040	0.17[a]
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	1.8[a]
Manganese	0.290	0.590	0.830	0.130	0.470	—
Zinc	0.050	0.050	0.020	0.020	0.150	0.32[a]
Boron	0.050	0.080	<0.010	0.030	<0.010	—
Vanadium	<0.010	<0.010	<0.010	<0.010	<0.010	—
Calcium	21.800	13.600	22.100	20.700	11.600	—
Magnesium	7.700	1.700	7.500	7.800	5.400	—
Sodium	17.900	28.300	36.500	26.700	13.00	—
Arsenic	<0.010	<0.010	<0.010	<0.010	<0.010	0.04[b]
Antimony	<0.020	<0.020	<0.020	<0.020	<0.020	1.6[b,e]
Selenium	<0.010	<0.010	<0.010	<0.020	<0.010	0.76[c]
Thallium	<0.010	<0.010	<0.010	<0.010	<0.010	0.04[b,e]
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.0000017[b]
Tin	<0.020	<0.020	<0.020	<0.020	<0.020	—
Silver	<0.020	<0.020	<0.020	<0.020	<0.020	0.0041[a]

a = Criteria for Freshwater Aquatic Life - total recoverable assuming a hardness of 100. mg/L as $CaCO_3$ (CWA)
b = Criteria for Freshwater Aquatic Life
c = Acute Toxicity Criteria for Freshwater Aquatic Life (CWA)
e = Apparent Threshold Limit Values (CWA)

TABLE 7

Army Creek Landfill
New Castle, Delaware
Army Creek Water Quality

Base/Neutral Organic Compounds (ug/l)*

Location	Date	Bis(2-ethylhexyl) Phthalate	Di-n-butyl Phthalate
Upstream	Sept. 1983	13.2	83.6
Downstream	Sept. 1983	NF	40.1
Surface Water or Criteria		3.0[a*]	3.0[a*]

* Analyzed by New Castle County Laboratory

NF = Not Found

a = Criteria for Freshwater Aquatic Life for Phthalate Esters (CWA)
* = Apparent Threshold Limit Values (CWA)

TABLE 8

Army Creek Landfill
New Castle, Delaware
Army Creek Water Quality

Total Inorganic Concentrations (mg/l)

Location	Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium*	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc	Iron	Manganese
Upstream	Sept. 1981	<0.010	<0.002	<0.0005	0.0016	0.015	0.0064	0.0127	0.0005	0.110	<0.050	<0.0005	<0.002	0.090	2.78	0.160
Downstream	Sept. 1981	<0.010	<0.002	<0.005	0.0015	0.0176	0.0068	0.0077	0.0001	0.080	<0.050	0.0006	<0.002	0.130	2.150	0.400
Surface Water Criteria		1.6[b,e]	0.04[b]	0.0053[b,e]	0.000025[c]	0.021[b]	0.022[c]	0.17[c]	0.000017[c]	1.8[c]	0.76[d]	0.0041[c]	0.04[b,e]	0.12[b]	--	--

Analyzed by New Castle County Laboratory

* Aquatic Threshold Limit Values (EWA)
** Chromium probably leached from container by using HNO_3 to polymethane containers.

a ...er Quality Criteria for Human Health - Fish and Drinking Water (
b ...eria for Freshwater Aquatic Life (EWA)
c ...teria for Freshwater Aquatic Life - total recoverable (expound)
d - Acute Toxicity Criteria for Freshwater Aquatic Life (EWA)

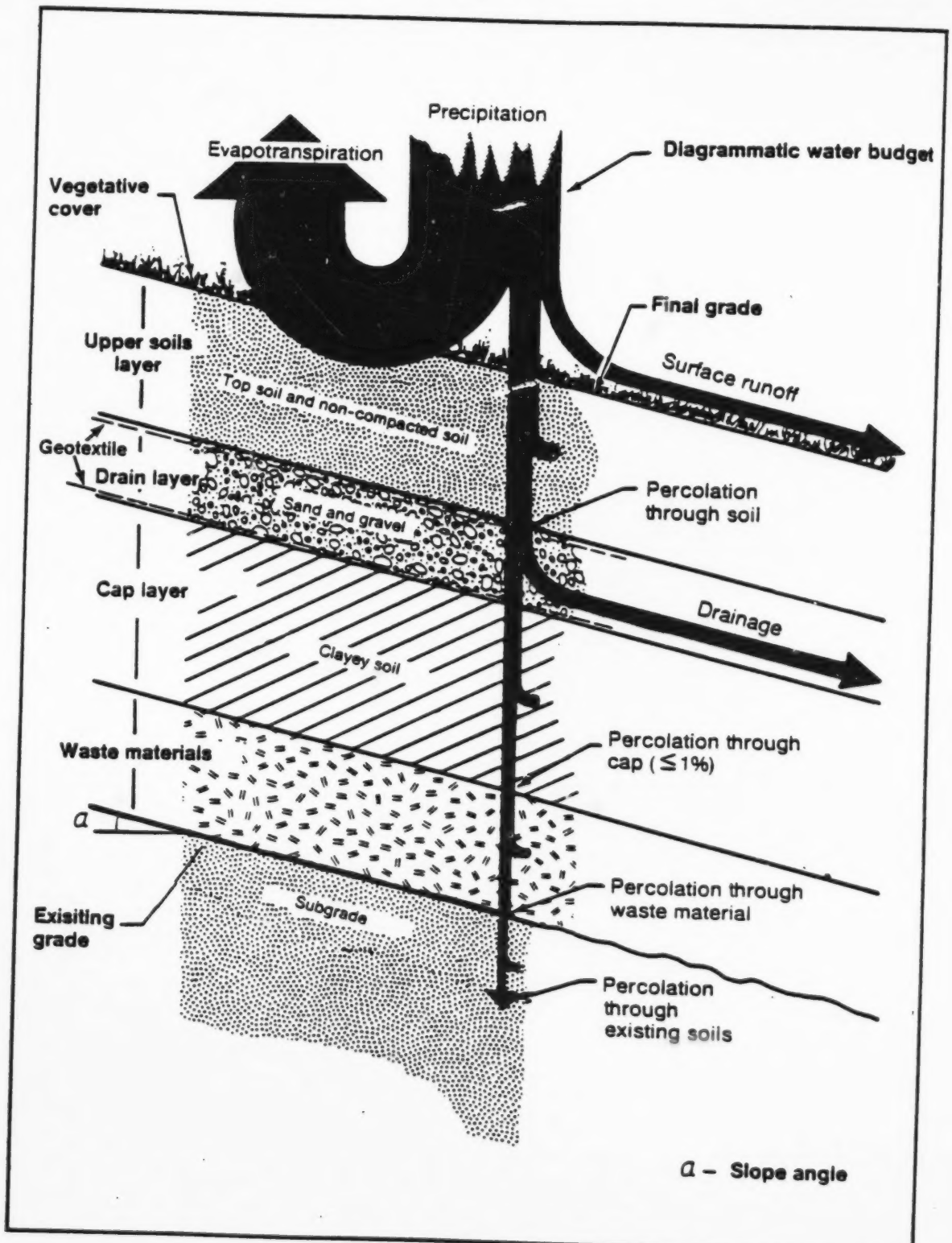
TABLE 9

Army Creek Landfill
New Castle, Delaware
Army Creek and Pond Sediment Quality
Total Inorganic Concentrations (ppb)
DNREC Sampling and Analysis

Total Concentration	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8
Iron	21,902,000.	9,505,000	44,010,000.	18,530,000.	45,175,000.	27,962,000.	2,867,000.	18,259,000.
Manganese	167,000.	190,000.	274,000.	398,000.	845,000.	1,320,000.	24,260.	87,020.
Chromium	18,490.	10,210.	25,540.	<10,000.	14,920.	14,930.	<10,000.	11,570.
Silver	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.
Zinc	87,270.	90,920.	274,000.	70,750.	143,000.	240,000.	22,240	91,060
Lead	21,400.	142,000.	175,000.	25,410.	70,630.	56,750.	10,110.	31,690.
Cadmium	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.	<10,000.
Mercury	<500.	<500.	<500.	<500.	<500.	630.	<500	<500.
Arsenic	<3000.	<3000.	9260.	<3000.	5470.	13,540.	<3000.	<3000.
Selenium	<500.	<500.	710.	<500.	<500.	<500.	<500.	<500.
Barium	42,800.	38,310.	234,000.	79,720.	145,000.	76,660.	<10,000.	57,380.

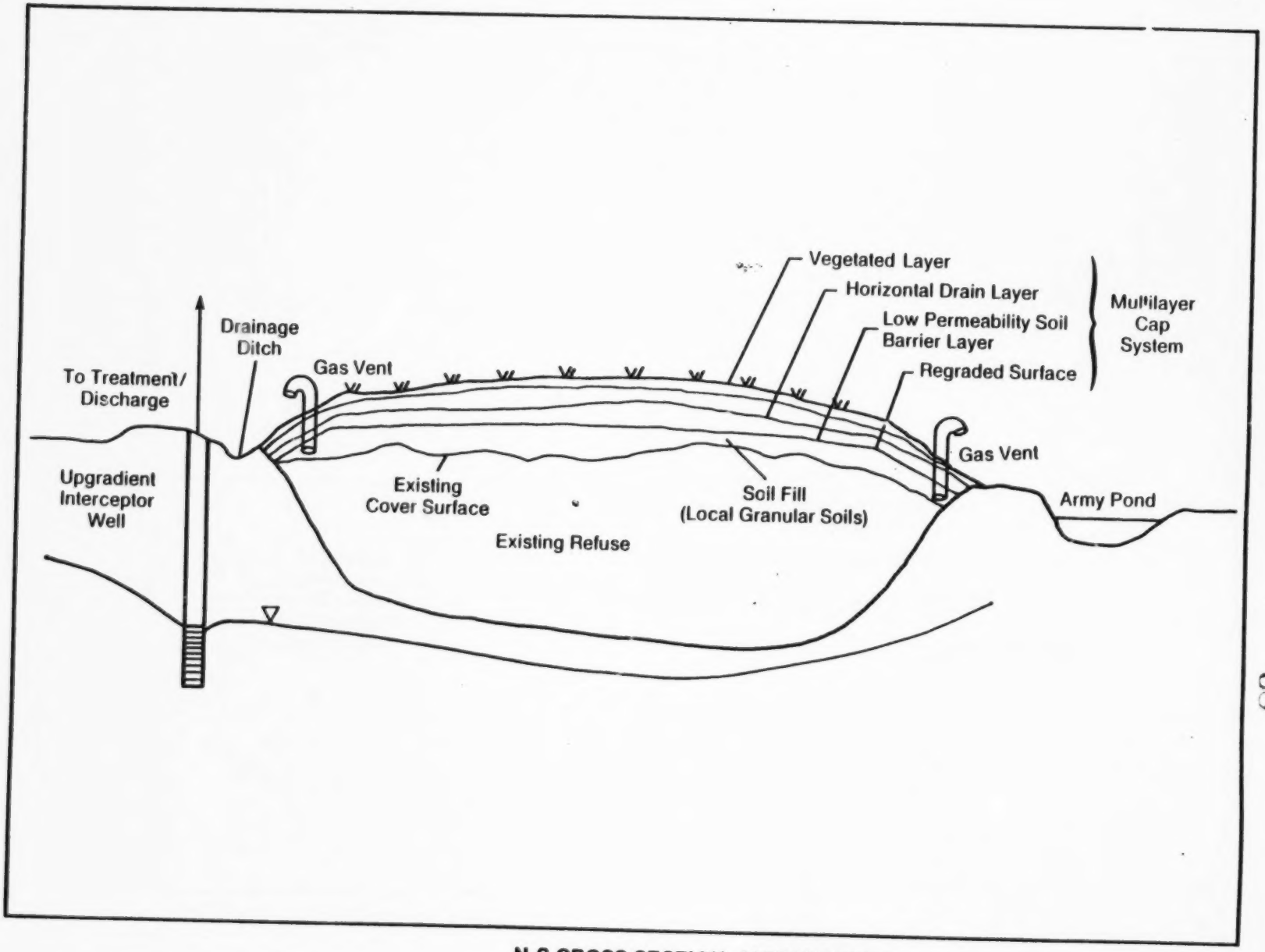
Station 1 = Army Creek, West of Route 13
Station 2 = Army Creek, East of Route 13, Upstream of Weir
Station 3 = Army Creek, Pond Entrance
Station 4 = Army Creek, Pond Effluent
Station 5 = Army Creek, Under Railroad Bridge
Station 6 = Army Creek, Tidal Gate, East of Route 9
Station 7 = Gravel Pit Pond
Station 8 = Intermittent Stream East of DS & G

* Toxicity permissible concentration on land-ecologic effect.



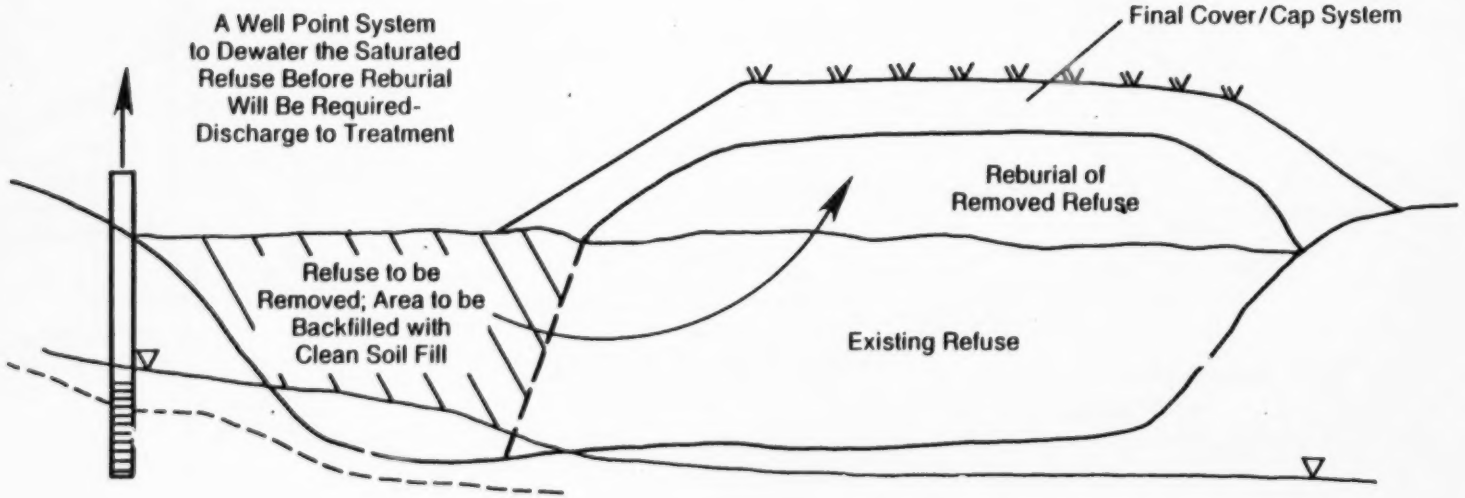
MULTILAYER CAP SYSTEM PROFILE

FIGURE 5



N-S CROSS SECTION: ALTERNATIVE 4

FIGURE 6



W-E CRC SECTION: ALTERNATIVE 5

FIGURE 7

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TABLE 10

REMEDIAL METHOD COST ESTIMATES - Army Creek Landfill

Remedial Method	Total Capital Cost	Total Monitoring/Maintenance Cost		Total Present Worth Cost
		Annual	Present Worth (1)	
1. No action - monitoring	$250,000	$113,000	$1,065,000	$1,315,000
2. Downgradient pumping	$120,000	$272,000	$2,565,000	$2,685,000
3. Downgradient pumping and landfill capping	$12,030,000	$307,000	$2,895,000	$14,925,000
4. Downgradient pumping, landfill capping and upgradient pumping	Non-phased $12,340,000 Phased $12,030,000/ $310,000(2)	$393,000	$3,705,000	$16,045,000
		$306,000/$87,000(3)	$3,140,000	$15,290,000
5. Partial removal and on-site disposal, capping and downgradient pumping	$35,500,000	$296,000(4)	$2,430,000	$37,930,000
6. On-site incineration and downgradient pumping	$113,500,000	$272,000	$2,565,000	$108,250,000(5)
7. Off-site disposal at an approved landfill and downgradient pumping	$239,900,000	$272,000	2,565,000	$243,000,000

(1) Assumes present worth values based on a discount rate of 10% over 30 years.

(2) Assumes construction of upgradient pumping in 10 years @$310,000.

(3) Assumes operation of upgradient pumping in 10 years @$87,000/yr.

(4) Anticipated annual cost for 15 years after which annual cost is reduced to $96,000.

(5) This cost estimate is a result of subtracting the revenue figures from the total cost of the project.

TABLE 11

SUMMARY EVALUATION OF REMEDIAL ACTION ALTERNATIVES

ALTERNATIVE	COST ($1,000) PRESENT WORTH	PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS (PERFORMANCE-RELIABILITY IMPLEMENTABILITY-SAFETY)	INSTITUTIONAL REQUIREMENTS COMMUNITY RESPONSE CONCERNS	COMMENTS
1. No-Action o Monitoring Only	1,315	Without hydrologic controls, the contaminate plume will migrate further downgradient, resulting in potential human exposure by ingestion of organic constituents above the 10^{-6} Health Risk Criteria. The continued production of leachate, would not be controlled continuing impact on Columbia and Potomac aquifer.		Publicly Unacceptable Does not follow proposed guidelines of the EPA Ground water Protection Strategy. (CERLCA)	Does not attain applicable public health and environmental standards.
2. Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment	2,685	Reduces public health risk by containing the contaminant plume by means of a hydrologic divide. Has prevented possible abandonment of Potomac aquifer as source of water supply. The quantity of leachate generated from precipitation and ground water infiltration through the landfill will not be reduced - impact on environment will continue.	Downgradient recovery system has to date a history of effectiveness. Water quality of downgradient water production supply wells has been maintained. System requires periodic rehabilitation and maintenance.	The discharge of recovered/treated ground water must be performed within necessary permitting/approval process. NPDES permit required if treated discharge is to Army Creek.	Does not attain applicable environmental standards - present cover over landfill does not meet RCRA guidelines.
3. Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment Landfill Capping o Site Regrading and Surface Wate Diversions	14,925	Public health risk reduced by containing the contaminant plume by means of a hydrologic divide. Infiltration of precipitation through the landfill will be reduced over 96% by capping the landfill. Reducing leachate production should hasten	Regrading and backfilling of the existing cover is required to establish a site contour pattern to promote run-off away from landfill. Regrading to flatten out existing slopes to assure slope stability may be required.	The discharge of recovered/treated ground water must be performed within necessary permitting/approval process. NPDES permit required if treated discharge is to Army Creek.	This alternative attains applicable and relevant public health and environmental standards.

TABLE 11

(continued)

ALTERNATIVE	COST ($1,000) PRESENT WORTH	PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS (PERFORMANCE-RELIABILITY IMPLEMENTABILITY-SAFETY)	INSTITUTIONAL REQUIREMENTS COMMUNITY RESPONSE CONCERNS	COMMENTS
3. (continued)					
o Gas Venting		ground water cleansing but at an unknown rate. Infiltration into landfill of ground water from Columbia aquifer along northwestern side will continue. Contamination of both Columbia and Potomac aquifer continue.	Side slopes in the flood plain must be protected with rip rap cover.	There are RCRA design standards for surface capping. Proposed cap will meet RCRA guidelines. Public concerns about new activity at the landfill site must be addressed. All state erosion, sediment, and dust control ordinances would apply during construction and until a vegetated cover is established.	
4. Phased Approach Phase I Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment Landfill Capping o Site Regrading & Surface Water Diversions o Gas Venting Phase 2 Upgradient Controls* o Monitoring o Discharge to Appropriate Treatment	15,290	Public health risk reduced by containing the contaminant plume by means of a hydrologic divide create by downgradient pumping. Infiltration of precipitation through landfill reduced over 96% by capping the landfill. Present cover provides only 32% reduction in infiltration. Upgradient pumping network will significantly reduce the ground water entering landfill along northwestern side, reducing further leachate production. After initiating upgradient pumping (Phase 2) short-term effect is continued use of a water resource. Upgradient pumping will hasten ground water cleansing long-term effect is less pumping of downgradient network.	Same as #3 & in addition; The efficiency of the upgradient pumping well scheme is largely dependent on the amount of recharge through the landfill and the water level elevations in Army Creek. As with the downgradient system, the upgradient will require periodic rehabilitation (initially) and maintenance.	Same as #3 & in addition, well installation permits for the new upgradient wells have to be obtained from the State of Delaware.	Under the phased approach the effect on the ground water quality as a result of capping the landfill will be monitored and assessed prior to initiating upgradient pumping. This alternative attains applicable and relevant public health and environmental standards.

*Pumping used for evaluation

TABLE 11

(continued)

ALTERNATIVE	COST ($1,000) PRESENT WORTH	PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS (PERFORMANCE-RELIABILITY IMPLEMENTABILITY-SAFETY)	INSTITUTIONAL REQUIREMENTS COMMUNITY RESPONSE CONCERNS	COMMENTS
4. continual Non-Phased Approach	16,045	Same as #4a	Same as #4a	Same as #4	Under the non-phased approach all remedial action will be initiated simultaneously.
5. Partial Removal and Disposal On-Site o Regrading, Backfilling, Surface Water Diversions Landfill Capping o Gas Venting Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment	37,930	Public Health Risk reduced by containing contaminant plume. Addresses environmental impact caused by ground water infiltration by eliminating the source of leachate generation and has additional benefit of not removing additional water from local source as in Alternative 4. Capping of eastern section after removal and disposal of western section will significantly reduced precipitation infiltration. Source removal and capping of landfill will hasten a ground water cleansing reducing long-term pumping. During excavation dust & odor problems will occur as well as the draining of free water from saturated refuse.	Refuse in western part below the water table will have to be dewatered by upgradient pumping. Recovered water will require treatment. Free liquid drainage and dust can be controlled using standard construction approaches but odor will be more difficult. A potential slope stability problem may result along the exposed cut section between the eastern and western section as excavation results in deep cuts into refuse. Special/hazardous wastes encountered will require special handling and transport.	Same as #3 in addition, odor would be a significant concern to the local public. Increased noise is also a concern during excavation and disposal operations.	This alternative attains applicable and relevant public health and environmental standards.
6. On-Site Incineration o Complete Removal o Dewatering of Refuse by Upgradient Pumping Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment	108,000	Same public health and environmental benefits as Alternatives 4 and 5. Air pollution control devices required under RCRA will reduce the release of contaminants into the air. Incinerator ash and residue backfilled on-site in areas above ground water table.	Suitability of Potomac Formation to support incinerator foundations. Raw refuse from off-site will be transported to the site and mixed with the saturated waste to make it burnable.	Compliance with Delaware Solid Waste Authority's master plans. On-Site incineration regulated under RCRA. A Hazardous Waste Management Facility Permit is required. Public opposition can be anticipated.	This alternative was screened out because its cost is of an order of magnitude greater than Alternatives 4 and 5 which offer similar public health and environmental benefits.

TABLE 11

(continued)

ALTERNATIVE	COST ($1,000) PRESENT WORTH	PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS (PERFORMANCE-RELIABILITY IMPLEMENTABILITY-SAFETY)	INSTITUTIONAL REQUIREMENTS COMMUNITY RESPONSE CONCERNS	COMMENTS
6. continued		Dust, odor, and drainage of free liquids from the saturated waste are problems associated with the excavation of landfill refuse. Other environmental and health concerns are with transport of raw refuse to the Army Creek Site including noise, dust and perceived vector problems.		National Ambient Air Quality Standards (NAAQS) apply - will require Clean Air Act (CAA) permits.	
7. Off-Site Disposal by Landfilling at Approved Site o Complete Removal of Landfill o Dewatering of Saturated Refuse by Upgradient Pumping Downgradient Pumping o Monitoring o Discharge to Appropriate Treatment	243,000	Same public health and environmental benefits as Alternatives 4, 5, and 6. Dust, odor, drainage of free water from the saturated refuse, and noise problems will arise from the excavation and hauling operations.	Availability of RCRA approved sites.	Transportation of hazardous waste to an off-site disposal facility requires RCRA TSDF permits. Public opposition to this alternative resulted in the cancellation of an earlier plan for a disposal site adjacent to Army Creek site.	Same as #6.

RESPONSIVENESS SUMMARY

ARMY CREEK LANDFILL SITE
NEW CASTLE COUNTY, DELAWARE

SEPTEMBER 1986

This community relations responsiveness summary is divided into the following sections:

Section I: Overview - A discussion of the EPA's preferred remedial action alternative.

Section II: Background of Community Involvement and Concerns - A brief history of the community's interest in and involvement with the Army Creek Landfill Site, including a discussion of concerns raised by community members and officials during remedial planning activities.

Section III: Summary of Public Comments Received During the Public Comment Period and Agency Responses - A summary of comments categorized by topic and followed by EPA responses.

Section IV: Remaining Concerns - A description of remaining community concerns that should be considered as the EPA and the State of Delaware Department of Natural Resources and Environmental Control (DNREC) conduct the remedial design and remedial action at the Army Creek site.

In addition to sections I through IV, a list of EPA community relations activities conducted at the Army Creek site is included as Attachment A of this responsiveness summary.

I. Overview

The Remedial Investigation (RI) Report and the Feasibility Study (FS) Report were released to the public for review and comment on August 21, 1986. This marked the opening of the comment period, which extended until September 22, 1986. During the comment period, the EPA recommended a preferred remedial alternative from among the seven alternatives presented in the FS report.

After careful review of and consideration of all alternatives developed in the FS, the EPA and DNREC recommended the phased approach described in Alternative 4. This alternative includes the following components:

- Regrade the landfill surface to assure a finished compacted surface and install a capping system to minimize infiltration of rainwater.
- Continue the operation of the downgradient recovery well network.
- Evaluate the capping system and the downgradient pumping network for five years after the cap is installed to assess system effectiveness during operation. This evaluation would include, but not be limited to, monitoring water levels, pumping rates and water quality.
- After the evaluation period, if conditions necessitate, install upgradient controls to intercept lateral groundwater inflow on the northwestern boundary of the landfill.
- Continue monitoring of water levels, pumping rates and water quality.

II. Background of Community Involvement and Concerns

The Army Creek Landfill Site is located 2 miles southwest of New Castle, Delaware. The site is located on the northwest bank of Army Creek, which discharges into the Delaware River within 1 mile of the site. A residential development of more than 200 homes, Llangollen Estates is the nearest and most directly affected community. Just beyond this residential area lies the Artesian Water Company's well field, which supplies water to approximately 5,000 people.

The site was originally used as a sand and gravel pit. The New Castle County purchased the property in 1960 for use as a municipal landfill. Waste was deposited from 6 to 35 feet deep over an area covering 44 acres.

The residents of Llangollen Estates expressed their concern over the landfill as early as 1960, when plans for the municipal landfill were announced. The Llangollen Estates Civic Association filed an unsuccessful legal action to prevent the landfill from opening.

Throughout the active life of the landfill, residents of Llangollen Estates complained of rodent and odor problems. The number of complaints decreased substantially after the landfill was closed and covered with sand and soil.

In 1971, one Llangollen Estates resident complained that the water in her home had an odor and stained her porcelain fixtures. The water was analyzed and found to be contaminated, as was water from several other private wells. Presently, most Llangollen Estates residents are receiving municipal water supplied by the Artesian Water Company.

Residents of Llangollen Estates have followed closely the activities of all government agencies involved with the Army Creek Landfill. However, communication between government agencies and citizens during the time between signing of the FS Consent Order with New Castle County and release of the FS document was limited. This lack of communication was a major concern voiced by citizens during the comment period.

III. Summary of Public Comments Received During the Public Comment Period and Agency Responses

Technical Questions/Concerns Regarding Remedial Alternatives

1. A resident asked for an explanation of upgradient controls.

   EPA Response - The installation of upgradient controls is an option to be considered after the five-year evaluation period. The capping system and the downgradient pumping network will be evaluated for five years after the cap is installed to assess the system's effectiveness. If necessary, upgradient controls such as recovery wells upgradient of the landfill or trenching around the landfill would be installed to prevent lateral flow through the fill material.

2. One commentor asked what was being done at present to control the contamination into Army Creek.

   EPA Response - Contaminated groundwater pumped from the recovery well system at the Army Creek Landfill is discharged into Army Creek. Presently, DNREC is drafting an NPDES permit which will establish safe and appropriate levels for contaminants now being discharged into Army Creek.

3. One commentor questioned if the quality of the recovery well water would improve upon completion of the remedial action and if so, would it be plausible to pump this water into the Wilmington Waste Water Treatment Plant instead of into Army Creek.

EPA Response - Once the landfill is capped, the quality of ground water should improve. Pumping into the Wilmington Waste Water Treatment Plant is an option that will be addressed at a later date.

4. A resident asked how much water was presently being pumped into Army Creek.

   EPA Response - Approximately two million gallons per day.

5. Another resident asked how close the contaminants are to the well field.

   EPA Response - The contaminant plume extends to approximately 1500 feet away from the Artesian well field.

6. Several commentors questioned the timetable for the remedial action.

   EPA Response - Negotiations with responsible parties generally are limited to 90 days. It is anticipated that the Record of Decision (ROD) will be finalized by September 30, 1986. The actual design phase of the project could take up to one year to complete. After the design phase, the remedial action will be implemented. Once the action is completed and the cap is in place, the site will be monitored for five years to determine if the levels of contamination decrease. An evaluation will then be made regarding the need for upgradient controls.

7. One resident questioned what factors the Feasibility Study (FS) took into consideration.

   EPA Response - The Feasibility Study considers not only what contaminants are in the landfill, but the pathways by which exposure can occur to both humans and the environment. The purpose of the FS is to evaluate various alternatives to remediate the source and the contaminated groundwater.

Public Health/Environmental Concerns

1. A resident asked if anyone could say with reasonable assurance that there will not be a lateral flow of contamination into the landfill.

   EPA Response - EPA will evaluate the effects of any lateral flow upon completion of the cap. If the effects are significant, upgradient controls will be installed.

Public Participation Process

1. Several residents expressed their concern over the lack of information and opportunities for public participation at the Army Creek site.

EPA Response - EPA representatives offered to make themselves available for small group meetings to discuss the FS in detail. EPA also stated that there will be many more opportunities in the future for residents to be involved with the decisions made at the site.

2. Several commentors requested additional time to review the FS and the preferred alternative. Several residents said they were outraged at being given only 21 days to comment on a study that took 2 years to prepare.

   EPA Response - A decision to extend the public comment period could not be made at the meeting, but would be taken into consideration with the other comments received, both written and oral. (The comment period subsequently was extended from September 15 to September 22 as a result of this request.) EPA explained that citizens would have input for the duration of the project, and that this Record of Decision could not address recovery well discharge.

3. Some residents indicated that EPA should begin the cleanup as soon as possible, and that additional delays should be avoided.

   EPA Response - None.

4. A representative of the Llangollen Civic Association asked if EPA would meet with knowledgeable community members once they had a chance to review the FS.

   EPA Response - Agreed.

Cost/Funding Issues

1. A commentor questioned what the cost of the remedial action would be.

   EPA Response - The present worth cost of the remedial alternative over the next 30 years approximately is $15 million, this includes capital costs.

2. One resident asked how much New Castle County had spent to date on the Army Creek Landfill.

   EPA Response - New Castle County has spent $3.85 million to date on the Feasibility Study and the installation, operation, and maintenance of the recovery wells.

3. The Artesian Water Company claims that its pumping capacity has been reduced due to groundwater contamination. The company believes it should be compensated for this loss as part of this CERCLA action.

EPA Response - This question has been discussed at length by EPA, the Artesian Water Company ("Artesian") and New Castle County before and during generation of the Feasibility Study. It is Artesian's position that it has been forced to draw less water from its wellfield because of the contamination leaching from Army Creek and operation of the recovery well system. Artesian regards the reduction in capacity as a response cost under CERCLA. New Castle County is of the view that, if Artesian has lost any capacity from the wellfield, it is for reasons other than pollution from the landfill. The County has argued that Artesian has never been entitled to draw more water than it presently takes from the wellfield, by virtue of state authorization and salt water intrusion. Artesian has sued New Castle County, and some other parties over this question, and no final resolution of that case has been reached.

Both Artesian and the County vigorously presented their respective positions to EPA during preparation of the Feasibility Study. The regional staff consulted with headquarters about this issue, and the final result was a memorandum from Gene A. Lucero, Director, Office of Waste Programs Enforcement, to Steve Wassersug, Director, Hazardous Waste Management Division, Region III. In short, the position of EPA is that replacement of aquifer capacity is not a goal for this CERCLA cleanup. The wellfield currently in use is being protected by the existing recovery well system, and other remedial measures recommended for this site should prevent future contamination of the aquifer related to contamination from the landfill.

Attachment A

Community Relations Activities Conducted at the
Army Creek Landfill Superfund Site.

° August 3, 1984 - EPA announced signing of a Consent Order with New Castle County to perform a Feasibility Study for the Army Creek Landfill.

° November, 1984 - EPA completed a community relations plan.

° August 18-20, 1986 - EPA contacted local officials and citizens regarding release of the FS and set up information centers in the community.

° August 21, 1986 - The FS was sent to 4 information centers, and a press release announcing completion of the FS was distributed.

° September 10, 1986 - A public meeting was held to discuss the findings and recommendations of the FS.

° September 15, 1986 - The comment period was extended until September 22, 1986.